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Executive Summary

This deliverable is devoted to build a homogeneous mapping of the Community Networks netCommons is working (or intends to work) with in Europe, plus a general overview of the many facets of the Community Network concept around the world, with the goal of providing a sort of taxonomy plus a rough global quantification of the phenomenon. For the development of the analysis framework we have worked in close collaboration with a few of the Community Networks (CNs) that are most representative and more relevant, one way or another, to the netCommons project. This report builds on and extends D1.1 (M6) with further elements of commons theory, more details and coverage of additional CNs, a mapping of CN web sites to show the inter-relations among them, a typology of international CNs, and a expanded taxonomy for comparison and typology.

The report first of all reviews and partially re-define the concept of commons in the context of modern society and technologies. Next a description of the general framework for the comparative analysis of different CN instances is given trying to set a "reference conceptual architecture" that can help understanding different organizational models and different implementations of CNs.

After this general and theoretical analysis, the deliverable reports a detailed analysis of a selection of CNs: guifi.net, FFDN, Ninux, AWMN, Sarantaporo.gr, Freifunk, and CNs from INCA, that are representative of European initiatives. These CN have inspired the development of the general framework; An extensive list of many self-proclaimed CNs around the world and further details collected from a few of them closes this descriptive part of the Deliverable as an Appendix.

This report concludes task T1.1: "Mapping of CNs" and contributes to achieve objective O1.1 "Mapping CNs providing a description of relevant CNs structure and organization to other WPs".

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List of Acronyms

ADSL	Asymmetric Digital Subscriber Line
AP	Access Point
AWMN	Athens Wireless Metropolitan Network
B4RN	Broadband for Rural North
CN	Community Network
CAPS	Collective Awareness Platforms for Sustainability and Social Innovation
CPR	Common Pool Resources
DFS	Dynamic Frequency Selection
DSL	Digital Subscriber Line
FFDN	French Data Network Federation
FIRE	Future Internet Research and Experimentation
FF	Fraifunk
0xFF	FunkFeuer
FONN	Free, Open & Neutral Network
FOSS	Free Open Source Software
FTTH	Fiber To The Home
FTTP	Fiber To The Premises
ICT	Information and Communications Technology
ISM	Industrial Scientific Medical
ISP	Internet Service Provider
IX	Internet eXchange
IXP	Internet eXchange Point
LGBT	Lesbian, gay, bisexual and transgender
NCL	Network Contract License
NOC	Network Operation Center
NWNP	Nepal Wireless Networking Project
OAN	Open Access network
OF	Optical Fiber
OLSR	Optimized Link State Routing Protocol
OLSRv2	Optimized Link State Routing Protocol version 2
SLA	Service Level Agreement
VOIP	Voice Over Internet Protocol
VPN	Virtual Private Network
WCN	Wireless Community Network

WiFi	Wireless-Fidelity: the IEEE 802.11 family of standards
WISP	Wireless Internet Service Provider

1. Community Network Infrastructures

This deliverable provides a comparative analysis of the organizational structure of Community Networks CNs around the world, with focus on the European ones. For the development of the analysis' framework, we have worked with a few of the most representative CNs, which are most relevant, one way or another, to the netCommons project. This deliverable extends D1.1 (M6) in that it includes more CNs instances; it provides more details in their analysis; and develops further their typology with new elements. The report is organized along different sections that include:

a) An introduction to the concept of community networking infrastructures in the context of data networks;

b) A description of the general framework for the comparative analysis of different CN instances, mostly driven by Ostrom's principles;

c) A detailed analysis of a selection of CNs (guifi.net, FFDN, Ninux, Sarantaporo.gr, AWMN, Freifunk, INCA/B4RN) that have inspired the development of the general framework;

d) A comparative analysis of different CNs, coupled with elements for a typology and discussion;

e) An extensive list of many self-proclaimed CNs around the world and their organisational models (in an appendix).

The work builds on results from previous work in the Collective Awareness Platforms for Sustainability and Social Innovation (CAPS) P2PValue project[1] and the CONFINE Future Internet Research and Experimentation (FIRE) project[2], particularly the sustainability model for CNs reported in [4] and [1].

From the netCommons proposal, the description of task 1.1 is as follows:

> *"Based on public and easily collectible information, this task will produce a comprehensive mapping of the main and most developed CNs around the world, with a focus on the European ones, sketching their organizational models, governance, and the environmental factors that shape these CNs, including socio-economic and regulations among others. Indicators about local impact will also be considered, to relate the internal organisation with the service provided to the communities each CN is rooted in, and the impact they have on them. It is specifically relevant to look at social diversity, in terms of how diverse different stakeholders in each community are represented. Gender aspects will also be considered. T1.1 will produce the first version of its deliverable (D1.1 v1) at M6 [5]. This is a milestone that will feed several other tasks and be the basis to chose a subset of CNs to involve in the socio-technical experiments of the project.*
>
> *After this initial 'passive' monitoring phase, the work will continue with interviews, joint work, literature review, and desk research to collect information about communities and classify their organisational structure and methods. The expected outcome will be the identification of relevant and differentiating characterisation and classification of CNs, details about each network and model, and benchmarking according to their social impact and utility. At the end of the task the final version of D1.1 (v2) [6] will be issued."*

[1] https://p2pvalue.eu
[2] https://confine-project.eu

1.1. Network infrastructures

According to [7] a computer network is defined as:

> *"a telecommunications network, which allows computers to exchange data. In computer networks, networked computing devices exchange data with each other using data links. The connections between nodes are established using either cable media or wireless media."*

Computer networks, also referred as "data networks", provide an artificial medium for digital communication and access to information across distance and time that complements our natural limited capacities as evolved apes, to communicate in the acoustic space, see in a narrow frequency band of visible light, and access information in the physical space around us. Traditionally telecom services and access to the Internet were seen as an option, a luxury for corporations and the club of those citizens willing to pay premium to benefit from these artificial "superpowers".

The infrastructure that provided these commercial services was managed by national telecom monopolies and later by telecom incumbents and other commercial (for-profit) operators. In recent times, the growing adoption of data networks as the best, and sometimes the only, option to communicate with many other people and access most information, has promoted that access to an essential (sometimes called "universal") service. That requires the involvement of governments legislating and regulating various aspects to guaranteeing to the public universal access to these privately provided services.

Furthermore, the evolution of services, both private and governmental, from commerce and entertainment to tax paying and education, has in recent years relied more and more on telecommunications services both as a means of reducing services costs and as a means to improve citizen service provision reducing the time needed to obtain the service and allowing service provision outside normal business hours.

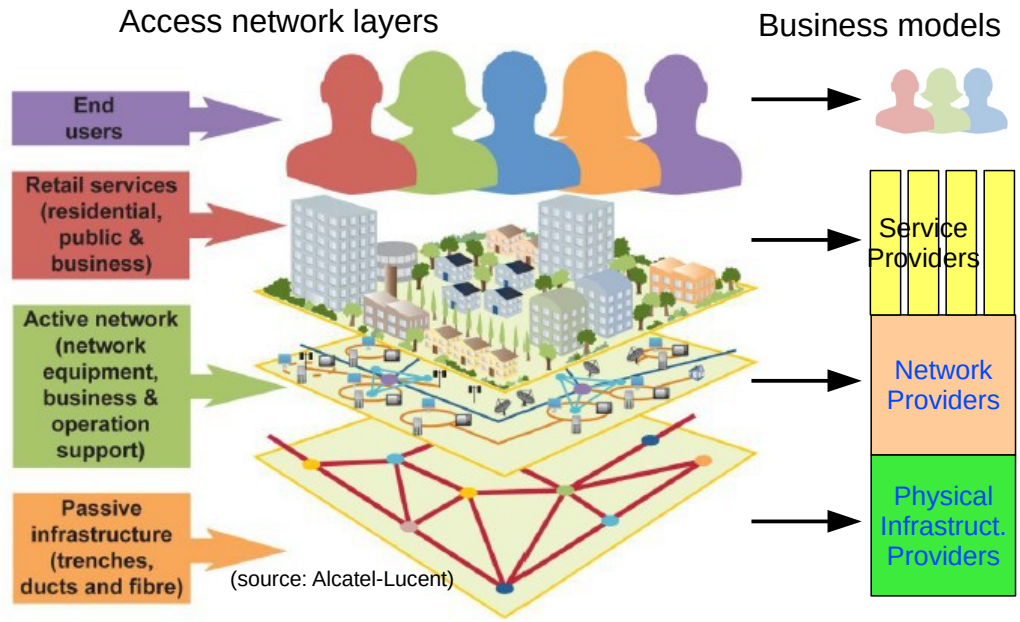

Figure 1.1: The components of a broadband network (with a focus on optical fibre) and the three service layers.

According to the broadband[3] investment guide of the European Commission [8] and supporting re-

[3]The term "broadband" is used to refer to fast data networks, in contrast to slow and narrowband dial-up telephone lines.

search [2], the structure of a modern network service consists of three inter-dependent layers: a) the passive infrastructure, b) the active infrastructure, and c) the delivery of service, as illustrated in 1.1. In the Open Systems Interconnection model (OSI model) [9] the passive infrastructure corresponds to layer 1 (physical), the active infrastructure corresponds to layers 2 (data link) and 3 (network), and the delivery of services includes the remaining layers (from transport to application).

The most typical passive infrastructures are the traditional telephone copper wires, TV coaxial cables, optical fibre, wireless point-to-point or multi-point links and the corresponding dedicated (licensed) or shared (unlicensed open access) spectrum. The active infrastructure typically comprises a diversity of data-link protocols matching the associated passive infrastructure. It converges in most cases to an IP network on top and is sometimes also combined with network virtualisation techniques.

These IP networks can offer a wide range of services such as interconnection to the global Internet, telephony as Voice Over Internet Protocol (VOIP), access to media content (such as television, radio, cinema), and can be accessed by personal client devices or servers, typically through Ethernet cables or WiFi (Wireless-Fidelity: the IEEE 802.11 family of standards (WiFi)) Access Point (AP).

The deployment and operation of these networks and services requires investments that feature large economies of scale in urban areas with many citizens (customers). The concentration of customers in small areas and their grouping in buildings, make it a great business for commercial telecom providers. As the population density decreases and the distance to major cities increases or the economic capacity of customers decreases, the margin for commercial exploitation decreases or becomes negative. However, there is growing consensus that it is important to provide these services to every citizen, in particular in remote areas that are generally under-served when compared to more urban areas, and even public services are sometimes provided only remotely. As a result, public administrations have devised policies that promote and try to ensure a minimum level of service for all citizens independently of their location. These policies range from subsidies to network operators in exchange for offering services in these areas, to public investment in the development of complementary network infrastructures, or definition of public (regulated) prices for key services.

However, network infrastructures are in most cases under the control of former monopolies, now telecom incumbents. These entities control the offer and have strong lobbying mechanisms in place to influence regulation and discourage competitors. Except for the most developed urban areas, the typical situation is of lack of competition, defined as “market failure”. The typical market structure is rather disappointing, with a very small set of large telecom providers acting as oligopolies and exercising cartel practice, which justifies public intervention [8]. This has been recognized as a critical challenge by ITU in a report [10] that explores and proposes options based on the principles of separation and sharing, typically managed by governments through legislation, regulation and subsidies. The most visible recommendations are:

- Extending access to fibre backbones: open access to bottleneck or essential facilities (like fibre infrastructures), that encourages the development of multiple providers of any size and scope, and promotes investment in a high-capacity infrastructure to unserved or underserved areas;
- Mobile network sharing: an equivalent to the previous but applied to the mobile network, applicable to both passive and active elements of the network;
- Spectrum sharing: promotion of the spectrum “commons”, with administrative, licensing, unlicensed bands, commercial or technical measures (like dynamic spectrum access or cognitive radio);
- International gateway liberalization: liberalization of international gateways, such as access to submarine cable systems, avoiding any anti-competitive control from incumbents;

- Functional separation: also known as operational separation, creating separate business divisions;
- Structural separation;
- Cost sharing and user sharing: sharing of a computer, mobile, Internet link, or content, across a group of people, such is schools, libraries, public-access tele-centres or shops.

Each of these measures can help develop new business models that can make a great difference in the expansion of the coverage and usage of data networks for the socio-economic benefit of every citizen in the world, and community networks can benefit from changes in these directions.

In Europe, the European Commission has introduced the cost reduction directive with measures to reduce the deployment cost of high-speed electronic communication networks (2014/61/EU) [11].

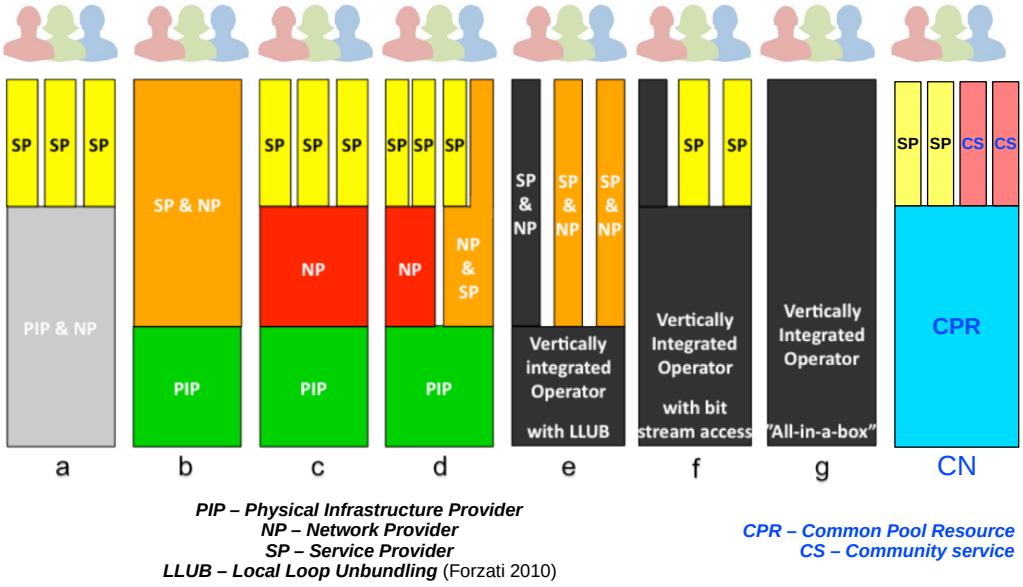

Figure 1.2: Different division and separation across the three service layers.

The typical business models of modern data networks follow one of the structural models depicted in Figure 1.2. Nevertheless, in some cases (and countries) functional or structural separation is in place to prevent anti-competitive, discriminatory behaviour by incumbents. The ultimate goal is to promote cooperative cost sharing schemes to reduce the cost of deploying infrastructures of any kind (telecom-related and others such as roads, water, electricity that require expensive civil works), and promote competitive offerings (market) to widen the choice and reduce the cost of services to customers.

In the rest of the report, we describe how community networks represent an alternative paradigm for developing network infrastructures and services. Such a paradigm can enable local communities to ensure their digital sovereignty, and take full advantage of the opportunities and benefits of co-operation and sharing towards their sustainable development. We will see how taking advantage of private and public initiatives and resources, communities can propose locally adapted self-organized cooperative schemes for realizing self-provided data networking solutions and sharing wireless links and spectrum, optical fibre, international gateways, and even sharing Internet connectivity with other members of the community.

1.2. Community Networks

Crowdsourced computer networks are network infrastructures built by citizens and organisations who pool their resources and coordinate their efforts. The coverage of under-served areas and the fight against the digital divide are the most frequent driving factors for their deployment, although contributors often mention doing things for experimentation, fun or the act of contributing to the development of a new telecommunications model per se as alternative motives.

The employed technologies vary significantly, ranging from very-low-cost, off-the-shelf wireless WiFi) routers to expensive Optical Fiber (OF) equipment [12].

The models of participation, organisation, and funding vary broadly across these networks. For example, some networks are freely accessible, whereas others are run as a cooperative, and others are managed by federations of microISPs. A few examples follow[4]. Broadband for Rural North (B4RN) in Lancashire, UK, and Nepal Wireless Networking Project (NWNP) are networks built in response to the lack of coverage of the conventional operators. B4RN deploys and operates optical fiber in a cooperative way. NWNP [13] is a social enterprise that uses wireless technologies to provide Internet access, electronic commerce, education, telemedicine, environmental and agricultural services to a number of remote villages. French Data Network Federation (FFDN) is a federation of French Do-it-Yourself ISPs comprising Digital Subscriber Line (DSL) resellers, Wireless Internet Service Providers (WISPs), collocation centres, and the like. HSLnet in the Netherlands or several members of the INCA association in the UK are examples of cooperative fiber-optic networks. Section 3.9 describes several of these cases that are part of the INCA association.

In Open Access networks (OANs) [14] anyone can connect to anyone in a technology-neutral framework that encourages innovative, low-cost delivery of services to users [10]. In other words, multiple providers share the same physical network. In many cases, these OANs are publicly owned. Municipalities sponsor or build the physical infrastructure (fiber-optic lines, wireless access points, etc.) offering wholesale access, and independent Internet Service Providers (ISPs) operate in a competitive market using the same physical network providing retail services. The most well-known example is the open-access network in Stockholm by the public company Stokab [15], having a key socio-economic impact in the region [16].

All these networks are very diverse in many aspects, and only a careful structural analysis will allow to classify each under one or several model types. This is the aim of this chapter.

CNs are a subset of crowdsourced networks that is characterised by being *open*, *free*, and *neutral*. They are open because everyone has the right to know how they are built. They are free because the network access is driven by the non-discriminatory principle; thus they are universal. And they are neutral because:

a) Any available technical solution may be used to extend the network;

b) The network can be used to transmit data of any kind by any participant, for any purpose.

Representative examples[5] are Guifi.net in Spain, Fraifunk (FF) in Germany, the Athens Wireless Metropolitan Network (AWMN) in Attica region of Greece, FunkFeuer (0xFF) in Austria, and Ninux.org in Italy.

All of them include thousands of links, mostly wireless[6], but gradually integrating also optical fiber

[4] BARN: http://b4rn.org.uk/, NWNP: http://www.nepalwireless.net/, FFDN: http://www.ffdn.org/en, HSLnet: http://www.hslnet.nl/

[5] guifi.net: http://guifi.net/, FF: http://freifunk.net/, AWMN: http://www.awmn.net/, 0xFF: http://www.funkfeuer.at/

[6] The term *wireless* was broadly used to refer to this type of community networks, so that many of these networks are

and optical wireless links.

Although CNs have already been studied from several angles [17, 18, 19, 20], there is still insufficient understanding of the practises and methodologies, which have given rise to such complex collaborative systems. There are many studies of guifi.net, the largest CN worldwide, from the structural [21, 22, 23], technological [24, 25, 26] or organisational [1, 27] points of view.

However, there is lack of a common framework to analyse the non-technological aspects of CNs that were key for the initial development of each initiative. After more than a decade the landscape has changed significantly in several dimensions. There are nowadays more and diverse technology options available. Its usage and integration has been simplified. The costs have been reduced. In summary, technology has commoditised. Overcoming technological barriers brings in the challenges of organization, and related issues around participation, sustainability, resilience, adaptability, impact, etc. The objective of the next chapter is providing a framework for the analysis of a selection of CNs looking at these challenges and issues.

referred to in literature as Wireless Community Networks (WCNs), because originally WiFi technologies were the only one cheap enough and not subject to licensing to enable their use in non commercial developments. Nevertheless, it is deliberately preferred to avoid the term, to decouple the concept of community networks from a particular technology choice.

2. An Organisational Framework for the analysis of Community Networks

2.1. Principles

The fundamental principles of most CNs, defined from the start to be fully inclusive, revolve around i) the openness of access to the infrastructure (usage), and ii) the openness of participation (construction, operation, governance) in the development of the infrastructure and its community.

Non-discriminatory and open access. The access is non-discriminatory because any pricing, when practised, is determined using a cooperative, not competitive, model. Typically this results in a cost-oriented model (vs. market-oriented) with the fair-trade principle for labour pricing. It is open because everybody has the right to join the infrastructure.

Open participation. Everybody has the right to join the community. According to roles and interests, several main groups could be identified as stakeholders: i) volunteers, interested in aspects such as neutrality, privacy, independence, creativity, innovation, DIY, or protection of consumers' rights; ii) professionals, interested in aspects such as demand, service supply, and stability of operation; iii) customers, interested in network access and service consumption; and iv) public administrations, interested in managing specific attributions and obligations to regulate the participation of society, usage of public space, and even in satisfying their own telecommunication needs. Preserving a balance among these or other stakeholders is desirable, as every group has natural attributions that should not be delegated or undertaken by any other.

When these fundamental principles are applied to an infrastructure, they often result in networks that are *collective goods*, *socially produced*, and governed as *common-pool resources*.

Thus, a CN could be viewed as a *collective good* or a peer property, in which participants contribute and share their efforts and goods (routers, links, and servers) to build a computer network. The peer property emerges under the operation of different Internet protocols provided that the community rules such as community licenses, are respected by all participants.

The development of a CN is an instance of both *social* and peer production. The participants work cooperatively at local scale to deploy network islands, and at global scale to share knowledge and coordinate actions to ensure the interoperability of the infrastructure that is deployed at local scale.

The *common-pool resource* is the model chosen to hold and govern the network. The participants must accept the rules to join the network and must contribute the required infrastructure to do it, but they keep the ownership of hardware they have contributed and the right to withdraw.

The next section presents in more detail the theoretical framework of Common Pool Resources (CPR). More generally, it explains how various theories framing the commons and peer production concepts can be used to better understand and analyze CNs.

2.2. Network Infrastructures as Common Pool Resources

The theoretical framework of the commons, in general, and that of commons-based peer production, in particular, serve as references for the development, management, and scientific analysis of CNs.

As already discussed, the underlying principle behind CNs is the firm conviction that the CPR framework presents the best way to run a network, as a critical resource for the development and sustainability of a community. CPRs were studied in depth by E. Ostrom [28]. In this section, we map her findings to typical CN instances and introduce other notions, which can be applied to study CNs and inform their development, sustainability and organization. We also introduce work by other theoreticians of the commons, whose main contribution was to adapt Ostrom's framework, originally developed for environmental local CPRs, to a broader diversity of resources, including knowledge, cultural and digital infrastructure and internet/spectrum.

According to Ostrom, a CPR typically consists of a core resource that provides a limited quantity of extractable fringe units. In our case, the core resource is the network, which is nurtured by the network segments the participants deploy to reach the network or to improve it. The fringe unit is the connectivity participants obtain. Resilient CPRs require effective governance institutions to keep a long-term direction and deal with the struggle to handle many actors and changes in a complex system. The long-term direction is defined as *sustainability* in remaining productive or operational under the fundamental principles of the CPR, and the short-term goal is defined as *adaptability* in reacting and adapting to change.

According to Frischmann [29], public goods and non-market goods, as network infrastructures, generate positive externalities (positive effects) that benefit society as a whole by creating opportunities and facilitating many other socio-economic activities. Therefore, open network infrastructures have great social and economic value, although their benefits are sometimes hard to measure. An infrastructure that is cooperatively managed and sustained leaves a greater margin of added value activities than commercial networking infrastructures developed competitively, making a great difference in developing regions or communities.

The commons can be fragmented into different subtypes. Ostrom developed her framework based on the analysis of case studies from local, mostly environmental, commons and extended her study with cases from knowledge commons, cultural and digital commons [30], composed by a resource, a community, legal rules, interaction (commoning), outcomes, evaluation.

Scholars further extended this work in an attempt to systematize knowledge commons with another collective volume [31], infrastructure commons with the example of internet congestion and network neutrality [32], and internet/spectrum commons [33].

These modified versions of Ostrom's framework look into the nature of the resource, of the community, the criteria of success, failure and vulnerability, and finally the political purpose such the importance of the commons for democracy and freedom.

Finally, the study of digital commons, with the major examples of free software and Wikipedia, gave rise to commons-based peer production (CBPP) [34]. The study of CPBB develops a political economy dimension to the study of a type of commons, by shedding light on the purpose and the underlying political values carried by commons as a sustainable alternative to the production by the state or the market only. The construction of such a common infrastructure will require policy action [35].

Atificial material commons

The "tree" of the commons has several branches: natural, knowledge and code, and artificial material commons that are key infrastructures for communities.

- The *natural commons*, studied by the classic Ostrom school, is brought by mother nature and the emphasis is in how these commons are self-managed sustainably for the benefit of a community and its preservation.
- The *immaterial commons* of knowledge and code that follows similar principles but requires a model for its collaborative production and its collective property, that Benkler [36] called "Commons-based peer-production". In this model, information and knowledge lie close to a non-rival resource, although the cost of finding it (requiring search engines) and accessing it (requiring content servers) consumes rival resources that can be congested (energy, digital devices as clients or servers). Moreover, knowledge and code do not constitute an exclusion barrier in developed societies, but generate exclusion in developing societies (cost of access and availability of access infrastructure such as servers, networks, client devices, energy, etc.)
- The *artificial material commons* are complex systems where peer production is applied to build some specific, traditionally material, resource resource pool (or system) that is critical for a community as an infrastructure or as a means for development. There is no clear cut between the natural commons and the artificial material commons, but a continuous transition whereby more and more value of the commons is related not to the natural resource managed, but to the complex engineering manipulation of it.

A traditional example of artificial material commons are the woods and lumber production and commerce in north-eastern Italy, traditionally managed by the *"Magnifiche comunità"* (magnificent community) [37, 38, 39, 40]. Here, on top of the natural resources, the communal benefit is earned and amplified through complex management systems, lumber transfer (from the mountains to the plains of northern Italy and the Venetian Republic in particular), and transformation: the resonance fir wood used in Cremona, Italy by Stradivari to craft his legendary violins was grown, cut, and seasoned by the 'Magnifica Comunità di Fiemme' in a management cycle lasting between one and two centuries and involving many different cultural and technical skills. The same woods and manufacturing are still today the source of the best resonance wood for string instruments and a source of high revenues for the Community.

Coming to modern times, a good example of artificial material commons are the pool of digital devices deliberately shared by a community that is willing to use, reuse, repair, refurbish and recycle [41] them for the sake of a sustainable circular economy.

Rivalry and openness

Another example are community networking infrastructures, the focus of this work. In the past, networking infrastructures were considered a club good (excludable and virtually non-rival as a commercial service) provided by for-profit ISPs to those fortunate to be in coverage areas and willing to pay the service fee. CNs are a social response to the wide recognition of connectivity as a basic human right, and therefore the network infrastructure connecting people becomes non-excludable. Modern network infrastructures are based on the packet-switching principle that provides a mode of data transmission in which a message is broken into a number of parts (packets), and transmitted via a medium that may be shared by multiple simultaneous communication sessions (multiplexing). That results in a multiple access scheme using switches and routers where packets are transferred or

queued, resulting in variable latency, limited throughput, and subject to network congestion if traffic gets close to its capacity. Despite conceptually non-rival, its practical implementation in a community of people, information and network services requires careful capacity planning to cope with demand, provide good quality of service and avoid network congestion that degrades the effectiveness of the network.

Under these assumptions, real (production) network infrastructures should be considered rival (networks have limited capacity, and every possible packet in a network can only transfer a specific amount of data and its presence in the network delays other packets). Without a careful design and planning, a network infrastructure gets imbalanced, congested and therefore exhausted as a resource system that produces connectivity as consumable. This is the case at least for high-data volume applications, like video/audio content or latency-sensitive applications such as audio or video conferencing and gaming. At the micro-level, the cost of sending one extra byte or packet in an idle network may seem nearly zero (non-subtractable) and therefore not subject to rivalry. In typical networks, this cost is subject to traffic loads and how they compare to the network capacity (over-provisioning is desirable and common practice in all networks, but too much of it is not economically efficient due to cost): additional traffic has a cost and an impact in the rest of the traffic.

Networks typically perform some kind of traffic engineering to operate efficiently (and manage rivalry), and network owners have to monitor the characteristics and volume of traffic to plan capacity and invest in its capacity when congestion starts to degrade the quality of service perceived by its users. Many Internet links tend to saturate from time to time. As network paths involve several link hops, some degree of congestion is nearly always present. In fact, Van Jacobson in the late 1980's faced the problem of Internet congestion and together with the research community came with several mechanisms for congestion control [42] in the most frequent transport protocol (TCP). Network users can generate large and virtually unlimited amounts of network traffic (e.g., each home user downloading content on a 1 Gbit/s optical fiber link) typically just limited by the speed and the cost of their link (and not by the cost of its data traffic). Internet peering disputes between "eyeball" ISPs, transit ISPs, or content ISPs, are not an exception [43], and typically capacity upgrades in network links result in elastic increases of traffic expanding and adapting very quickly to the new capacity of the link.

Therefore we can consider that production network infrastructures are typically subject to congestion, and therefore connectivity has to be considered rival. While commercial ISPs try to maximize benefit and minimize company risk in a competitive market (therefore an excludable resource sold at the highest possible market price), the goal of CNs is to maximize social inclusion, in terms of number of participants, coverage and cost, using a cooperative model where risks, costs and management is shared among the participants. This results in a network infrastructure that produces connectivity as close as possible to the ideal of non-exclusion, and under a peer property, peer production and peer consumption.

In fact, the recent verdict of the U.S. federal court classifying the Internet as a common carrier (type II), or the spirit of the European Regulation on a Single Telecom Market mandating network neutrality, imply an organisation or service that transports goods or people for any person or company and that is responsible for any possible loss of the goods during transport, under license or authority provided by a regulatory body [44]. A common carrier is distinguished from a contract carrier that transports goods for only a certain number of clients and maybe not anyone else. A common carrier holds itself out to provide service to the general public without discrimination. Community Networks are not common carriers offering a service to anyone external to the network infrastructure, but open for anyone to join to access to contribute infrastructural resources and consume connectivity, and participate in the management and governance of the commons. As with common carriers, there is a commitment to no

discrimination and, hence, neutrality at all levels (access, participation, contribution, consumption). In summary, whereas a common carrier provides open access to the service, without exclusion other than the rules of access that may require to pay the service fee, in commons (and common property/self-management) members of a certain group can exclude non-members.

In that respect, infrastructure commons also favour the *political autonomy* of their participants, that is the ability for an individual to make choices and determine the course of her life free of external manipulative forces. As Yochai Benkler explains, autonomy is adversely affected by concentration and increased top-down control over communications resources:

> *"All of the components of decision making prior to action, and those actions that are themselves communicative moves or require communication as a precondition to efficacy, are constituted by the information and communications environment we, as agents, occupy. Conditions that cause failures at any of these junctures, which place bottlenecks, failures of communication, or provide opportunities for manipulation by a gatekeeper in the information environment, create threats to the democratic autonomy of individuals in that environment. The shape of the information environment, and the distribution of power within it to control information flows to and from individuals, are, as we have seen, the contingent product of a combination of technology, economic behavior, social patterns, and institutional structure or law." [34]*

2.3. Stakeholders

In general, an instance of commons is composed by a resource (the CPR), which is governed, according to rules adhering to the commons frameworks, by a community. This community may be composed by several types of actors. This section presents these actors, and more broadly the whole space of stakeholders, in a CN based on their roles, status, rights, and obligations.

It is essential to clearly identify the interests and specific tasks of the different stakeholders, and the relevant conflicts of interest. In the analysis of multiple CNs described in the rest of this chapter, we have found there are typically four main stakeholders, as depicted in Figure 3.3. The *volunteers*, the initiators of the project are responsible for the operation of the tools and mechanisms of governance and oversight. The *professionals* contribute quality of service, and their *customers* bring the resources, which make the ecosystem economically sustainable. The *public administrations* are responsible for regulating the interactions between the network deployment and operation, and the public goods, such as the occupation of public domain. All participants that extract connectivity must contribute infrastructure, directly or indirectly, and can participate in the knowledge creation process.

As the community managing a commons can be decomposed into various sub-communities depending on their role, the bundle of rights [45] will become a useful additional analytical grid to further decompose these tasks. The bundle of rights includes rules on the right of:

- *Access:* to enter and connect,
- *Withdrawal:* to extract resources from the system (obtain connectivity from a network),
- *Management:* to regulate usage, make improvements,
- *Exclusion:* to determine who will have access and how this right can be transferred, and
- *Alienation:* the right to sell a portion of the resource (e.g. by professional participants selling connectivity to their customers).

Different stakeholders relate to property rights. That, as Schlager presents [45] for natural resources, results in different access rights. Authorized users (customers) are given access (connecting) and with-

drawal rights (consumption or harvesting connectivity), through services provided by professionals or volunteers, to have equivalent rights to manage or govern the infrastructure.

The rules related to joining a CNs (*access*), imply adding a network node and accepting the formal or informal rules of the community (sometimes the community license or any kind of agreement). The mechanism (inclusion and exclusion) is defined by a deliberation process among the assembly of participants (having the right for management) and generally implemented and automated by a software service to register, enroll and configure the new resource unit (link and router). Once the connection is successful the user is immediately able to consume connectivity but also provide connectivity to others connected to his router. Therefore users are both consumers and producers of connectivity, and joining implies also extending the resource system in the new location and allowing third parties to extend it beyond. Access and connectivity usage is not limited to the registered user, but usually his right is informally shared with anyone connected to his local (e.g. household) network (authorized users).

In a few cases, people may join a CN using an end-user client device (terminal or host such a laptop, desktop, server, or mobile device but not a router, using a WiFi Access Point or Ethernet cable). In this case, these participants are pure consumers of connectivity (or some specific application service) that do not extend the resource system. While not all CNs include this case, that form of participation allows externals or visitors (anonymous or not) to take advantage of the connectivity provided by the infrastructure, like if it were an open-access resource for the benefit of the local community at large. Sometimes this type of access is provided in collaboration with an institutional partner like a government along indefinite periods (e.g. community access in an area for those registered in the public library, educational or telecentre) or definite periods (e.g. an event, an emergency). In some cases these clients are registered users that can consume connectivity in a place with a client device in one place while contributing connectivity and expanding the infrastructure in another part of the network.

Compared to natural commons, CN make fewer or no distinctions among participants: all members are co-owners (of his network router and link), proprietors (enabled to participate in management and inclusion/exclusion), claimants (management). Only informal users of local/home networks and customers of member ISPs can be considered plain authorized users (consumers but not citizens in political terms). This level of potential participation is supported by computer-based coordination tools, although the effective decisions and actions are effectively performed by a small minority of motivated and trained participants.

We even find squatters: participants that do not follow the community rules and hide from the rest of the community, but use the network infrastructure (no contribution, at risk). Frischmann in [46], studying efforts to extend Ostrom's work on environmental commons to knowledge/cultural commons, showed how the classical free-rider of the tragedy of the commons can be applied and which lessons can be learned.

Withdrawal is related to obtaining connectivity from the community infrastructure. It is difficult to think about a community or regional network infrastructure that is isolated, connecting, for instance, different community members, local schools and organisations purely among themselves. Given the value of expanded connectivity, informally expressed by the Metcalfe law [47], connectivity to the Internet represents a key added value. Different CNs have different approaches to adding Internet connectivity and managing it in a sustainable way. While in some cases this connectivity is intrinsically part of the infrastructure commons, in other cases is left outside the infrastructure commons, as an additional service. Sometimes it is considered equivalent to "content", an added value ingredient that is simply transferred inside packets of connectivity and that goes through an Internet gateway,

and therefore considered a separate concern and left outside the network commons. Some other communities provide default basic Internet connectivity to any node in the CN (e.g. with a common Internet interconnection gateway subsidized by third parties such as server hosting in a community data centre). Another approach is that Internet connectivity is contributed by volunteers, connected to both the CN and their own (personal) Internet access, that share for free (or a fee like in the FON commercial service) some of their spare connectivity with other community members. Another way is that Internet connectivity is managed and provided by a cooperative or crowdfunding model by a group of participants that share a common connection to the Internet in one network location and use tunnels over a CN to divide and access their share of connectivity remotely (see section 3.3 for an example).

Several CNs also act as an Internet eXchange Point (Internet eXchange Point (IXP)) or just Internet eXchange (IX) that is connected to other external ISPs and networks, and therefore is able to allow paid or peering transit traffic. In these cases, the CNs facilitate the cooperative aggregation of Internet capacity among several participants in the CN, which reduces the cost for each (cost sharing: paying only for their portion of traffic instead a full link) and the reliability of the Internet access (economies of scale: potentially benefiting from more redundant links than what a single participant could individually afford). (see section 3.2 for an example).

Each community has its own implicit or explicit agreements for the contribution (of resources) and withdrawal rights (operational level), and collective-choice level (*management*, *exclusion* and *alienation* in natural resources). Network infrastructures, as artificial material commons, may also require investments in infrastructure (maintenance, repair or expansion) and economic compensations among participants to correct imbalances and promote investment (reduced risk or incentives). Different compensation or investment mechanisms are considered such as crowdfunding, contracts, accounting systems, local currencies. Conflict resolution, like in many other commons, is a critical component to the stability and sustainability of the network infrastructure. Typically some reputable or experienced participants are selected for the role of mediation and arbitration.

The constitutional choices in each CN vary, according to the local characteristics and initial decisions. In some cases, a community license has been developed or adopted and agreed. The license should be explicitly or implicitly endorsed by all participants, and prescribe rules that determine rights or freedoms around *joining* the network and extending this right to anyone (as part of a resource system), *using* the network (provided no harm is intended or done, including traffic neutrality), providing services and content to others (for profit or not), and transparency (understanding, sharing knowledge) to promote participation in its management and governance. The transitivity of all rules result from the pooling nature of a network.

2.4. Implementation of the governance

This section discusses how the governance architecture presented in Section 2.3 can be implemented as tools in diverse CN.

2.4.1. Communication tools

A network infrastructure commons has an important challenge in communications as usually participants are not only widespread, but also they tend to depend on the network infrastructure to communicate and coordinate: the community manages its commons network infrastructure by using that

commons with components contributed by themselves. This creates and extra level of commitment[1] but also makes the task more complex by the need to rely mostly on digital communication. Due to the widespread of locations and the technical nature of its participants, collaborative tools of all kinds tend to flourish in CNs. The following are the most common:

Website It is the main participation and coordination tool. It integrates all the software tools described above, providing a complete platform for designing, deploying, and operating CNs.

Mailing lists These tend to be the preferred communication method for discussion. Mailing lists may have global, geographic, or thematic scope, and are most open for participation.

Social Media Local or global platforms for social interaction and information sharing are used to handle documentation and discussions. Working groups are public by default, but closed ones also exist to protect sensitive information.

Face-to-face meetings Face-to-face meetings play a very specific role in strengthening social relationships. Local meetings can be quite frequent (usually periodic: weekly, monthly, etc). In these meetings the participants work on their projects and help newcomers to join the group and the network.

2.4.2. Participation framework

The legal framework for participation in the network may include:

License The formal or informal CN license of neutral participation and traffic management. Examples of that are the Network Commons License (NCL) or FONNC in guifi.net, the Wireless Commons Manifesto in Ninux.org, or the Picopeering agreement (PPA)[2]. The licence sets the fundamental principles and the articles precisely establish the participant's rights and duties. Ideally, it is written to be enforceable under the applicable legislation to mitigate uncertainty, and should be developed through a participatory deliberation process.

Legal entity that gives a legal identity to the initiative. Its foundational mission is to protect, promote, coordinate and arbitrate the network commons. Its authority is frequently based on the reputation of the people involved, more than the legal strength of the entity.

Collaboration agreements with third parties such as professionals, public administrations, third-party organisations.

2.4.3. Network management and provisioning software tools

CNs need community network management platforms [48] to manage the different components that make up the network infrastructure, configure devices and network elements, reduce errors, facilitate the maintenance and operation of the network and lower the entry barrier for participation.

These tools are typically integrated in the public or internal web site of the CN. Typical components may include:

Mapping tool that combines geographic maps with network maps to collect and share all the knowledge about the network and the participants involved in it;

IP addressing and routing tool to coordinate the IPs assignment and routing configuration;

[1] Typical terms are "Skin in the game" for involvement, "Eating your own dog food" for using your own tools, and the "sink or swim together" for the interdependency.

[2] FONNC: http://guifi.net/en/FONNC, PicoPeering: http://www.picopeer.net/PPA-en.shtml

Device configuration tool to automate the configuration of network devices;

Network monitoring tool to assess the status of the network, visualise usage, and identify problems or bottlenecks;

Network crowdfunding tool to coordinate the collection of voluntary contributions of money to fund new or upgrade existing nodes or links that could benefit several users directly or indirectly.

2.4.4. Governance tools

These are the socio-economic tools that CNs can develop to keep the infrastructure and the project/community itself operational. It is common to find tools for a) *Conflict resolution*, which may include a palette of graduated sanctions to resolve flame wars between participants that may threaten a given CN, and b) *Economic compensation*, to compensate for imbalances between investment in the commons infrastructure and network usage.

2.4.5. Sustainability

Analysing the design of long-enduring CPR institutions, Ostrom [28] identified eight principles, which are prerequisites for a sustainable CPR. We now discuss their application to these human-made resource systems that provide connectivity:

1. Clearly defined boundaries. The fundamental principles of open and non-discriminatory access, and open participation in the life of the network are accommodated into instruments such as the community license, the management tools, the specific collaboration agreements with professionals and third parties, which prevent exclusion and regulate open and fair usage of the resource.

2. Rules regarding the appropriation and provision of common resources that are adapted to local conditions. The congruence between appropriation (usage of the network) and provision (expansion of the network) is usually mediated by common network management and provisioning tools that assist in assessing the status of the network and its usage; also by tools that assist in the expansion of the infrastructure covering the mapping of the nodes, their configuration, and even the crowd-funding or cost sharing of new or upgraded network nodes and links.

3. Collective-choice arrangements that allow most resource appropriators to participate in the decision-making process. Complexity and transaction costs grow as the network grows in size (number of nodes, links, distance, participants). This complexity is managed by social structures with diverse representation from all CPR stakeholders, and such open structures as the local and global face-to-face meetings, and the digital participation tools such as social media and mailing lists. In all these structures, the community of those who use or participate in the construction of the resource can participate openly.

4. Effective monitoring by monitors who are part of, or accountable to, the appropriators. Monitoring is performed with the assistance of network management and provisioning software tools that provide a common information base about the history and status of the common infrastructure resource; and the lead of many local trusted senior members that rely on that open data and coordinate decisions when needed. These decisions are accountable, deliberated, reported in the communication tools, and recorded in the organisational history.

5. Graduated sanctions for appropriators who do not respect community rules. Each CN has its own conflict resolution system with methods to deal with users who negatively affect the common infrastructure resource.

6. Conflict-resolution mechanisms which are cheap and easy to access. Each CN has its own way to address these conflicts in a cheap, easily accessible, efficient, effective, and scalable manner, which enables it to address a wide range of conflicts around the network.

7. Self-determination of the community recognised by higher-level authorities. Each CN has its own way to validate and enforce its rules and structures according to the different levels of legislation.

8. In the case of larger CPRs, organisation in the form of multiple layers of nested enterprises, with small local CPRs at their bases. Larger CNs have second-layer organisations, providing a federated CPR with many aspects in common, and interacting with external organisations in the local and global scope in many aspects.

2.4.6. Adaptability - Adaptable Governance

The concepts and governance tools of CNs relate to what Ostrom [49] outlined as five basic requirements for achieving adaptive governance:

1. Achieving accurate and relevant information, by focusing on the creation and use of timely scientific knowledge on the part of both the managers and the users of the resource. Communities produce open knowledge about practices and experience, and work with the scientific community to co-develop and apply scientific knowledge for the best development, management, and usage of the CPR. Collaboration agreements with academic and research organisations such as this project is a proof of accomplishment of that criteria.

2. Dealing with conflict, acknowledging the fact that conflicts will occur, and having systems in place to discover and resolve them as quickly as possible. The facts about the CPR are collected and managed by the different network management and provision tools. The rules in each community license and collaboration agreements define the limits that determine conflicting situations, quantified and discovered by inspection of the facts collected by the previous tools.

3. Enhancing rule compliance, by creating responsibility for the users of a resource to monitor usage. The openness principle requires users to publish open data about the network and allow the monitoring of nodes and their traffic. This requirement is supported and facilitated by the network management tools.

4. Providing infrastructure, that is flexible over time, both to aid internal operations and create links to other regimes. Each CN has its own structure to understand and adapt to changes over time, oversee the evolution of the CPR, facilitate the internal operation, and maintain links with external organisations and other regimes that coexist, interact, and interoperate with the CPR.

5. Encouraging adaptation and change, to address errors and cope with new developments. Each CN has its own structure to play an overseeing and steering role (sometimes referred to as a second level or umbrella organisation). This role should be driving feedback, organisational learning, and forecasting.

2.5. Services provided

CNs provide *network connectivity*, local or regional IP networks that enable inexpensive interaction and access to local digital content and services. Local web content, files, video content of local interest can be accessed through the CN infrastructure. Local services that allow local communication are also offered, like VOIP services, web cams, environmental sensors, live video streaming, search engines, remote file repositories, backup storage, among many other community services.

In addition, once part of a local network infrastructure, there is the issue of interconnection and access to the global Internet. That can be reached through an Internet Service Providers (ISP) available inside a CN. These ISPs can be wholesale (transit for organisations) or retail (for individuals) commercial or non-profit providers (e.g. the community or a specific group or cooperative), citizens sharing their unused Internet access capacity with neighbours and friends, public or private organisations offering a limited Internet access as a complimentary service.

Furthermore, there are public and private agents concerned with facilitating Internet access for other local citizens or visitors, at least to content of local interest. It is quite common to find free and open Internet access, offered through WiFi access points in public locations. When connected to a CN, these WiFi accesses provide an entry point to the CN and its world of content and services, and through local ISPs to the open Internet. That kind of Internet access with limited functionality is widely recognized as not constituting unfair competition with commercial telecom providers[3].

Internet access through web proxies is clearly a limited form of access compared to an IP tunnel as the service is usually restricted to a set of protocols/ports, while it can enhance privacy as origin IP addresses are hidden. For these reasons, many non-commercial providers in CN provide that kind of Internet access service, available to local visitors through WiFi Access Points and remotely to other CN members, at no additional cost. This is an inclusive and cost effective model to provide limited Internet (typically Web) access, complementary to commercial offerings.

2.6. Implementation of the infrastructure and impact

Customary measures such as geographic spread, number of nodes and locations, number of actual and reachable participants, km of links help to quantify the implementation of a CN in a given community: the coverage and service is providing there.

However, assessing the local impact of CNs is difficult as it relates to the social value created by allowing additional users to access and use a network infrastructure [29]. Doing so permits or enhances the production of a wide range of downstream producers of private, public, and non–market goods.

It is clear that self-organized and self-provisioned network infrastructures contribute to truly universal service, dramatically lowering the barrier of access. This is realized through access to inexpensive commoditized hardware and software, spectrum and knowledge, much in a similar way as Free and Open Source Software and Technology has contributed to provide inexpensive options for access to software, contributing to sustainable development [50].

Another, more tangible, indicator of impact has to do with network access and usage characteristics by the local community. This is related to the accessibility of the network infrastructure by local citizens and the added value it provides to them. Customary indicators can be the volume of locally produced and served content, local services or applications, number of registered users, number of access points for client devices in public places, involvement of civil society organisations, number and type of open community events, training activities, participation and network support to community events, etc.

Social inclusion is a key opportunity for CNs as inclusive and participatory organisations. Complementary to creating opportunities for including everyone in the digital society, these commons infrastructures create opportunities to involve, support not only the unconnected but also balance, include and promote participation of minorities. That is the case for the gender imbalance, and the

[3] Checked against the National Markets and Competition Commission (Spain). Similar schemes can be found in many other national legislations

inclusion of vulnerable groups (”the excluded” or ”less included”) like migrants, linguistic minorities, Lesbian, gay, bisexual and transgender (LGBT) people, unemployed or with fragile employment, students, handicapped, ill-health, with non-stable homes, less educated.

CNs are complex and sophisticated objects mixing local deployment (as for natural commons) with global connectivity (as for digital commons), physical infrastructure with knowledge, and interacting with urban commons. Thus, our hypothesis is that a plurality of approaches will better inform our analysis beyond Ostrom's CPR. After exploring the other frameworks, netCommons will be able to contribute to the scholarship pool of the commons. In order to achieve that objective, more specific questions will be handled within T1.2 (governance tools, decision-making, licensing), T4.1 (legal environment), T1.3 (citizen advocacy and impact on the legal environment) and T5.2 (urban commons and the right to the city).

3. Organisational elements of Community Networks

After the description in the previous chapter of the general framework for the comparative analysis of different CNs driven by Ostrom's principles. This chapter focus on a detailed analysis of a selection of CNs that have inspired the development of the general framework. These are:

- guifi.net a community network that includes many local initiatives, with its general principles and governance tools.
- The set of communities of professionals (compensation tables) that extend guifi.net to run professionally-maintained network infrastructure commons.
- A local guifi.net community in Barcelona that exemplifies a local community can organise and build on the guifi.net principles to manage a local network infrastructure in a sustainable way with the participation of volunteers and professionals.
- The Athens Wireless Metropolitan Network (AWMN), mainly around the metropolitan area of Athens.
- Federation FFD (FFDN), a federation of 28 community networks mainly in France.
- Ninux, a CN originated in Rome but extended across Italy.
- Sarantaporo.gr, a CN connecting 14 villages in the rural area of Elassona in Greece.
- Freifunk, one of the oldest and largest in Europe, originated in Berlin and expanding to several central European countries.
- The Independent Networks Co-operative Association (INCA), a cooperative of networks independent from the incumbent "altnets", including CNs such as Broadband for the Rural North (B4RN).

3.1. guifi.net

3.1.1. History and Principles

Guifi.net was conceived in the spring of 2004. By April 3 several people interested in the subject gathered to share ideas and plan the first test. The results of the tests done on May 15 were established as the first permanent and stable links between the municipalities of Calldetenes, Gurb, Vic and Santa Eugenia de Berga, in the Osona county.

guifi.net is typically referred as a CN when in fact is the federation of many smaller groups, in many cases associated to a location (e.g. city, region, neighbourhood) or different ways of organisation (e.g. professionals, volunteers) or technological (e.g. infrastructure, wireless mesh). This section describes the guifi.net federation, and succesive chapters describe organisational elements of two representative participant communities: the professionals and its specific compensation system in section 3.2, and the eXO association mostly in Barcelona in section 3.3.

guifi.net is managed as a CPR, the core resource being the network infrastructure. Managing the infrastructure as a commons has some immediate effects such as the avoidance of the multiplicity of infrastructure because all participants operate on the same one, and the increase of efficiency of the

infrastructure in terms of saving costs and easing participation. The CPR, i.e. the guifi.net infrastructure, grows by each new network segment deployed by the participants to reach the network or to improve it. The reward for the contributors is the network connectivity that participants get [1].

For commercial services, the operation of guifi.net as a CPR translates into a reduced entry barrier for starting business ventures since the network infrastructure is available for usage to everyone in the community. This pertains to both individual and professional users so that participants can benefit from resource pooling and sharing and save individual investments. The knowledge about the network is open and the network is neutral: no barriers that artificially limit the scope of service creation.

Nonetheless, community networks, as any other CPR instances, are fragile. More precisely, since they are non-excludable, they are prone to congestion. Since connectivity is subtractable, they are subject to the free riding problem. Thus, efficient and effective governance tools are needed to protect the core resource from depletion [28], that is to say, to protect it from the *Tragedy of the commons* [51]. The network license and the conflict resolution procedures are examples of the tools developed by the guifi.net community to cope with these threats.

Collaboration tools and public information sets must also be in place to make the CPR viable. Aside from the standard mailing lists and web forums, guifi.net has developed a set of software tools to ease the design, deployment, management and operation of the network in a self-provisioning style.

For commercial enterprises, the degree of interaction with these collaboration tools will depend on the type of deployed service. However, they may be needed for commercial enterprises to be able to offer service level agreements (SLAs) for the services they offer to the customers.

The governance tools presented in Figure 3.1, which is a refinement of the one presented in [1], are the result of more than a decade of theoretical and practical work. Generally, the improvements in the governance system have been introduced in response to specific challenges, as they emerged in the course of time. Figure 3.2 presents the most relevant threats and needs faced over time, their context, and the governance tools developed in response to them. Tools and methodologies are under constant revision in an open and participative process chaired by the Guifi.net Foundation.

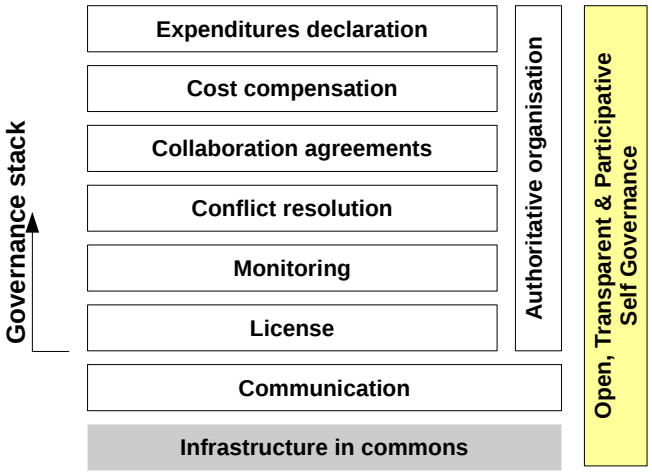

Figure 3.1: Governance tools (based on [1]).

3.1.2. Stakeholders

As depicted in Figure 3.3, there are four main stakeholders in guifi.net. The *volunteers*, the initiators of the project, due to their lack of economic interests, are responsible for the operation of the

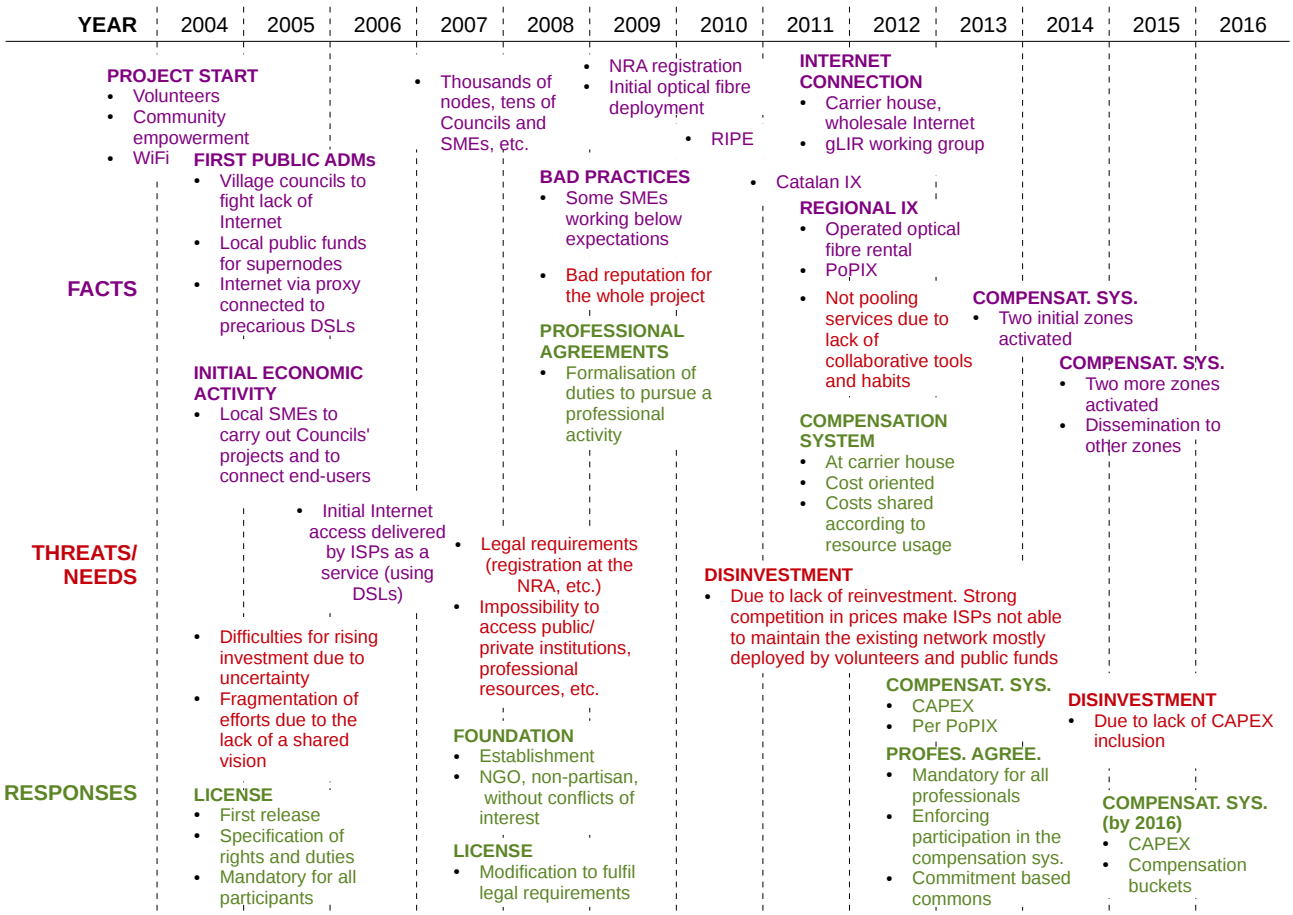

Figure 3.2: Facts, threats, and responses over time.

tools and mechanisms of governance and oversight. The *professionals* bring in quality of service, and their *customers* bring the resources which make the ecosystem economically sustainable. *Public administrations* are responsible for regulating the interactions between the network deployment and operation, and public goods, such as public domain occupation. All participants that extract connectivity must contribute infrastructure, directly or indirectly, and can participate in the knowledge creation process.

guifi.net is a success case for the coexistence of voluntarism and a well-established professional activity operating on the same CPR, i.e the communication network. Governance tools implemented in guifi.net play a critical role in keeping that balance. This is critical for the sustainability of the project, because, although the economic sustainability is mostly based on the revenue generated by professional activity, the governance and the harmonisation of the ecosystem is mostly carried out by volunteers.

3.1.3. Implementation of the governance

Communication and coordination tools

The technical skills among most participants, its distribution across the coverage footprint of the network and the need to coordinate decisions to keep the network infrastructure operational has resulted in the development of many tools to facilitate communication and coordination among participants

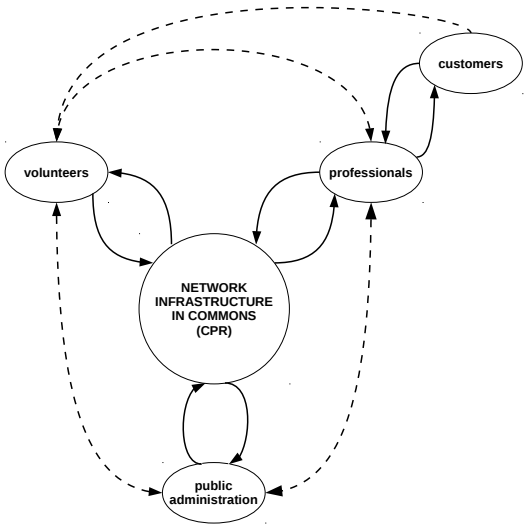

Figure 3.3: Stakeholders.

and the components of the infrastructure.

Software tools for network management and provisioning: The community of guifi.net has developed a set of software tools to ease the design, deployment, management and operation of the network in a self-provisioning style and supporting crowd-sourced efforts by members of the community given the intrinsic inter-dependence in the computer and social network. Most of them are integrated in the guifi.net web site.

Automation is an essential feature of the tools to reduce the users' learning curve and to avoid human mistakes. Public information sets are essential to make the network manageable, e.g. everybody can help to solve network failures or contribute to improve performance in bottlenecks.

Network map tool Network planning requires maps and several tools to calculate distances, line of sight clearance and select neighbour nodes. It is necessary to combine geographic maps with network maps to collect and share all the knowledge about the network and the people involved in it.

Assignment of IP addresses and routing configuration IPs assignment and routing configuration is fully automatised.

singleclick The configuration of all routers is fully automatised. The human interaction has been reduced to *copy & paste* or *reflashing* procedures. This helps to avoid configuration errors that can create conflicts in the network, and ease the process of node setup.

Community Network Markup Language (CNML) The CNML[1] is an XML specification developed in guifi.net through which the guifi.net database information is presented. All interactions should be done through it.

Network monitoring A fully distributed network monitoring system has been implemented. It has been key to help the community visualize usage and identify problems or bottlenecks.

Network crowd funding Since very early a tool was developed to coordinate the collection of voluntary contributions of money to fund new or upgrading nodes or links that could

[1] http://en.wiki.guifi.net/wiki/CNML/en

benefit directly or indirectly several users. The tool allows to create a proposal with a detailed plan with a description of the project, its cost and a deadline for contributions. If the target budget is met in the deadline the initiator will collect the money and launch the action. This mechanism has proven to be very successful to share costs among the community to upgrade bottleneck links or satisfying the need for new nodes for the benefit of several citizens.

Expenditures declaration A tool to allow the expenditures declaration has been developed as part of the economic compensation system. It also allows to know with a great precision the total amount of investment.

Communication tools: The most significant tools for communication among the participants are the *Mailing lists* [2], with global, territorial and thematic scope, open by default. *Social Media*[3] also open by default with a few exceptions to protect sensitive information. *Face to face meetings* play a key role in strengthening social relationships and sharing initiatives and knowledge. Local meetings are usually weekly or monthly based, with one yearly global guifi.net community meeting.

The *Grup LIR* (GLIR) is the technical group in charge of operating the guifi.net Network Operation Center (NOC). It consists mostly of professionals with a few volunteers too, with the group closed to protect sensitive information.

Participation framework

Participation in the community is organized by agreements: the community license shared by all participants, and a set of bilateral collaboration agreements between the entity representing the community, the guifi.net Foundation, and other organisations such as professionals or public administrations.

Network Commons License: The Network Contract License (NCL)[4] is the license that every guifi.net participant must subscribe to, developed and approved through a long standing open deliberation process. Its preamble[5] sets the fundamental principles and the articles precisely establish the participants rights and duties to join, use, understand, offer services as long as respecting and not interfering with the operation of the network, the rights of other users, and the neutrality of the network to contents and services. It is written to be enforceable under the Spanish legislation, as legal certainty is essential to stimulate participation and investment, which in turn, is at the base of any economic activity and therefore its sustainability. The license has been developed as part of a long lasting participatory deliberation process over several

[2] https://llistes.guifi.net/sympa/
[3] http://social.guifi.net/
[4] http://guifi.net/en/FONNC.
[5] Free, Open & Neutral Network (FONN) Compact preamble:

- *You have the freedom to use the network for any purpose as long as you don't harm the operation of the network itself , the rights of other users, or the principles of neutrality that allow contents and services to flow without deliberate interference.*
- *You have the right to understand the network and its components, and to share knowledge of its mechanisms and principles.*
- *You have the right to offer services and content to the network on your own terms.*
- *You have the right to join the network, and the obligation to extend this set of rights to anyone according to these same terms.*

years, with contributions from many community members, reaching a consensus, revised and approved in several versions by the community assembly.

Reference Authority: The guifi.net Foundation (*Fundació Privada per a la Xarxa, Lliure i Neutral guifi.net*) is a reference organisation founded by the guifi.net community that gives a legal identity to the community. As such, it plays a vital role for the coordination of the guifi.net ecosystem. Its foundational mission is to protect and promote the network held in commons.

As part of protection actions, it maintains the NCL and enforces its compliance when necessary. As part of the promotion activities, it carries out strategic and innovative projects and operates critical parts of the network infrastructure. It builds and maintains a set of tools (e.g. IP address space, legal identity, possibility to operate under its name) available to anyone, professionals included. The Foundation is composed by the Board of Directors (unpaid) and the employees.

Its authority is mostly reputation based because, as the rest of the participants, it just owns the part of infrastructure it has contributed to, and all its actions are constrained to its foundational mission of coordination and arbitration.

Collaboration agreements: aimed at strengthening the legal certainty derived from the NCL. These agreements result from the experience of many specific agreements over the years. The main set of agreements are with:

Professionals Any professional willing to carry out economic activities involving guifi.net infrastructure must sign a professional agreement with the Foundation. As part of it, the professional must state its level of commitment to the commons. There are tree options regarding contribution of his deployed infrastructure to the commons: *type A*, all of it, *type B*, a part of it only, and *type C*, nothing (that professional uses what is available but does not contribute at all). The agreement implies the acceptance of a set of Service Level Agreements (SLAs) aiming at facilitate the coexistence among the professionals. Once the agreement is signed, the professional is included in the economic compensations system, and he is allowed to benefit form a set of fundamental tools devised for professional operators (e.g., wholesale Internet access, Local Internet Registry, Internet eXchange point).

Third parties The Foundation also establishes agreements with third parties such as public administrations, private companies or universities. Through these agreements public administrations clarify their legal limitations to participate in telecommunication activities and limit responsibilities which fall outside of the scope of their statutory tasks[6]. Agreements with public administrations are rather common and most of them follow the same model. Agreements with private companies are rather specific and infrequent. They are used to set specific collaboration agreements either with the Foundation itself or to extend the collaborations to other entities that already have agreements with it. University agreements are used mostly for mentoring students and for undertaking research projects.

Governance tools

These are socio-economic tools developed by the community and managed by the Foundation to keep the infrastructure and the community operational and balanced. A balance is needed not only between volunteers and professionals, but also among professionals since, although they compete for

[6] In many countries, telecommunications are a public service that must be delivered by the private sector following clear rules set by the government. Public administrations are limited to specific actions (e.g., self-provisioning, under-served areas) and under controlled conditions (e.g., separate accounting, self-financed).

customers, they must coordinate and collaborate because they are sharing the infrastructure to reach their customers. The pillar of this collaboration is a system with several type of agreements based on the level of commitment with the commons and an economic compensation system for investments and resource consumption.

Conflict resolution system: A systematic and clear procedure for resolution of conflicts with a scale of graduated sanctions has been developed. [7]. It consists of three stages, conciliation, mediation and arbitration, all of them driven by a lawyer. The cost of the procedures are charged to the losing party or to both parties in case of a tie. This system has been developed based on experiences and defines a precise manner to help addressing these conflicts in a quick and standard way, with legal support, while scalable for a growing community.

Economic compensations system: Developed and implemented to compensate imbalance between investment in the commons infrastructure and network usage among professionals. Expenditures declared by the professionals are periodically cleared according to the network usage. The calculations are done by the Foundation and are made available to the professionals. The Foundation centralises and manages the billing system (each professional only makes or receives a single payment). A typical income for the Foundation is a percentage depending on each professional type[8]. In addition professionals are allowed to charge a reasonable amount for opportunistic connections[9] until their investment is covered.

3.1.4. Services provided

The community provides network IP service using a private network and also limited public (Internet) IP service over its wired and wireless infrastructure. In addition, in terms of network and application services, there are many announced services (2016): 10 direct Internet gateways, 330 Web proxies, 13 Voice over IP servers, 35 FTP or shared disk servers, 4 XMPP Instant Messaging servers, 6 IRC servers, 5 Videoconferencing servers, 54 Web servers, 9 Broadcast radios (music), and 4 Mail servers. There are probably many non-announced services, available to parts of the community.

3.1.5. Implementation of the infrastructure and impact

Currently, at the physical level, the guifi.net infrastructure combines several technologies: wireless and optical fibre are the most common. As of June 2016, guifi.net has a total of 31,273 operational nodes, accounting for 33,304 WiFi links (31,936 AP-Client and 2,836 Point-to-Point), more than 100 optical links, and making a total length of 60,000 Km. The 10 Gbps guifi.net optical backbone has three Internet uplink carriers (10 Gbps, 1 Gpbs and 300 Mbps).

According to [1] the capital expenditure (CAPEX) of the infrastructure built in commons is over 7.3 M€ and the operating expenditure (OPEX) over 3.0 M€ per year (2015).

The participation among stakeholders is quite diverse, (data from May 2016) with an estimate of 13,500 registered members, nine SMEs participating in the economic compensations system, 270 subscribers in the mailing list for professionals, 42 persons in the guifi.net NOC (GLIR), more than a hundred of councils actively collaborating with guifi.net, and only three cases of conciliation of conflicts since its introduction in 2013. The gender imbalance in the Information and Communications Technology (ICT) sector reflects in guifi.net. However several activities are performed in the

[7] Regulation and procedures for conflict resolution.
[8] Type A 10% (to cover administrative costs), Type B 50%, and Type C 100%.
[9] A client node that connects in a DiY manner to a supernode that has been paid by a professional.

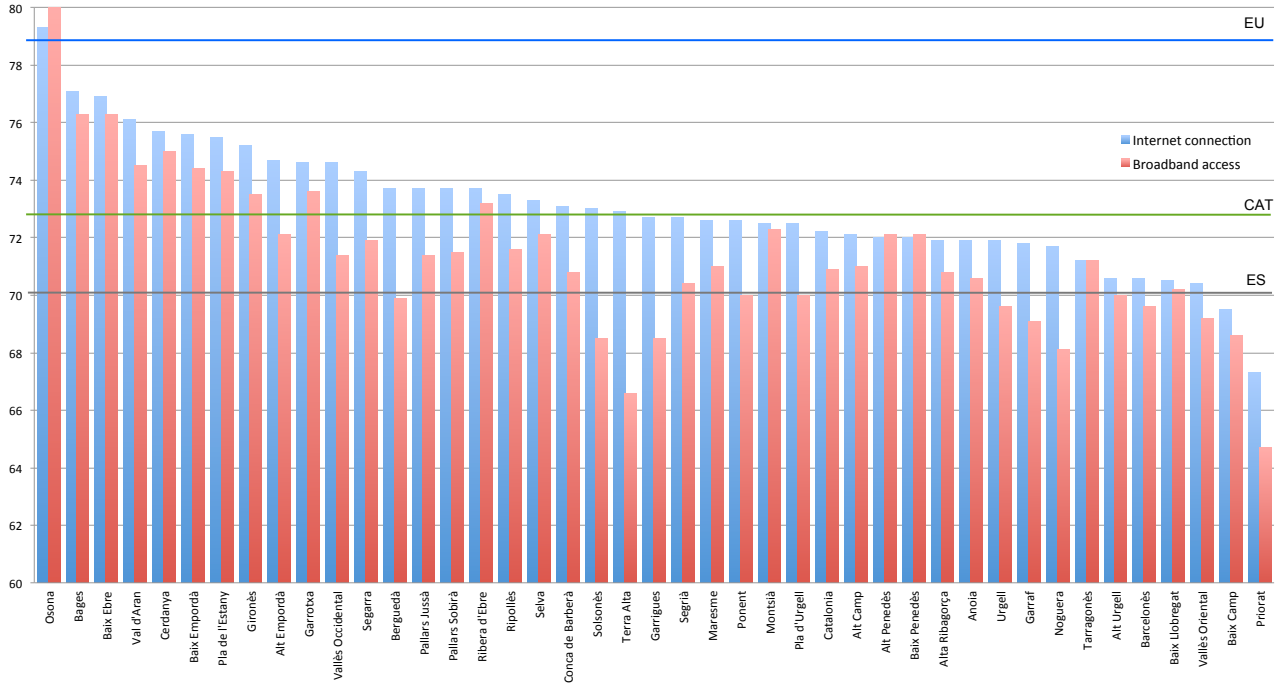

Figure 3.4: Households bandwidth and Internet access in Catalonia per county (*comarca*) in 2013. Source: IDESCAT [10]

community to deal with imbalances such as gender (and geek-girls), linguistic diversity (many languages written in the mailing lists and spoken in face-to-face meetings), interest diversity (including arts, cultural and social interests), and the inclusion of very diverse social groups that find in guifi.net an opportunity to work together towards the shared aim of expanding and governing the network infrastructure.

Recent statistics about penetration of the bandwidth and Internet access in the households of Catalonia per county in 2013, released by the public Catalan Statistics Institute (IDESCAT)[11] [52] show in Figure 3.4 that, despite the fact that Catalonia is about three points above the Spanish average, it is still seven points below the European average. Second, and most relevant regarding guifi.net impact, the Catalan county with the best results, and the only one above the EU average, is Osona, where guifi.net was born. The indicators of other counties with significant guifi.net presence, such as Bages and Baix Ebre, are also high when compared to similar counties where guifi.net is not present.

Currently, the main sources of economic activity in guifi.net are, on the one hand, those related to the infrastructure deployment and maintenance, and on the other hand, services delivered over the network. Although Internet access is still the most popular service, others such as VoIP, remote maintenance or backups have also been offered for a long time. New services such as video streaming and video on-demand are appearing, especially in the areas served by optical fibre. The growing trend toward local services being offered in the network infrastructure to a growing user base brings the need to a shared pool of configurable computing resources and platform services to manage that computing infrastructure.

[11] http://www.idescat.cat

3.2. Professional participants in guifi.net and the compensation system

The professional participants in guifi.net are organised according specific principles and governance tools. These were developed recently (during the last three years) to provide a more sustainable and more stable network infrastructure that can expand according to the needs of professional participants and the services they provide to their customers. All that has bootstrapped an economy around the concept of compensation tables which promotes investment, maintenance and coordination among professionals. The particularities of these professional communities, how these compensation tables work, and their contribution to sustainability justify a separate chapter from the previous.

3.2.1. History and Principles

The compensation tables formally started in January 2014 to address the problems of sustainability of the guifi.net infrastructure. It is an example of collaborative economy over a resource in commons. The first informal compensation system was in fact started in 2011 to handle the interconnection costs with the local traffic exchange (CATNIX)[12].

Guifi.net has been developing a comprehensive ecosystem based on the following driving principles:

- Sharing network infrastructure increases the efficiency (i.e., better performance or wider coverage for the same investment) of the network infrastructure because it stimulates cooperation, preventing duplication of efforts and facilitating economies of scale; this is particularly true in the case of optical fibre because, once in place and operated, it becomes a non-rivalrous asset (zero marginal production costs) due to its virtually unlimited bandwidth.
- The presence of economic activity is essential for the project's sustainability because it creates a dependency; thus, it generates the required resources to maintain and expand it.
- The professionals (i.e., individuals or enterprises that deliver services in return for an economic remuneration) deserve a fair reward for their work, but speculation on the network infrastructure is not allowed.
- Network participants have the right to satisfy their connectivity needs through their own as well as through the procurement of professional services in a fair competition market.
- The network must remain open, free, and neutral.

As shown in Figure 3.5, the network infrastructure is considered a CPR; thus, the physical assets are shared and collectively managed according to a collectively built governance system. In this model, ISPs compete to provide services to their customers but cooperate to deploy and operate the network.

The commons model optimises the intended effects on promoting the highest degree of competition in order to maximise the freedom of choice for the end users and to avoid monopoly of the open access model [54] because it increases competition by i) equalising business opportunities[13] ii) lowering the entry barriers due to cost-sharing and pooling resources/services, iii) disintermediation[14], vi) enabling service delivery to the whole network, and iv) reducing the tasks of the change of supplier to a simple equipment reconfiguration.

[12] [53] is published as an extended version of this chapter and presented in the GAIA SIGCOMM 2016 workshop.

[13] The redistribution of opportunities is achieved by enforcing the ISPs to pool their network assets or by issuing a cash penalty.

[14] The physical layer and the network operator agents disappear.

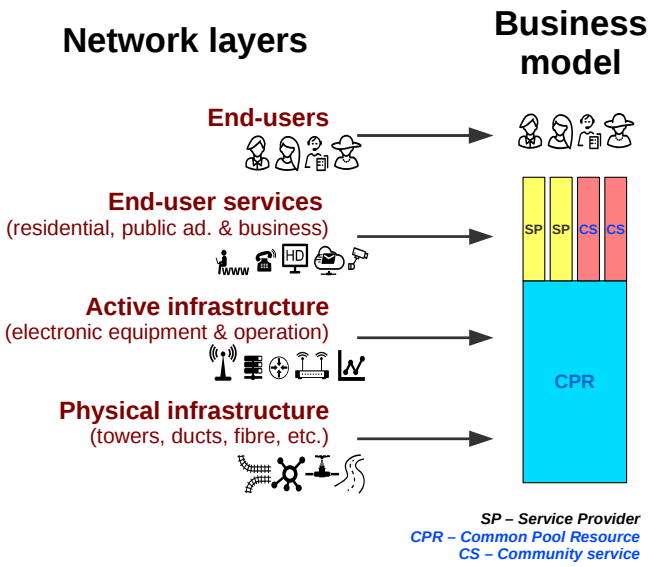

Figure 3.5: Access network layers vs Guifi.net business model (using Forzati's [2] representation).

3.2.2. Stakeholders

The professionals (i.e., individuals or enterprises that deliver services in return for an economic remuneration) which deserve a fair reward for their work, constitute the main target for the compensation tables. However, other organisations involved in the sustainability of a given network area can be involved too.

For that we aim to provide specific insight into the economic aspects of Guifi.net that are essential to its sustainability, particularly when it scales up and involves professional participants. In the rest of this section (3.2), we address the following topics:

- The cost-sharing mechanism, including cost calculations and sharing criteria,
- The reinvestment flows,
- The analysis of the gathered data and lessons learned, and
- The planned improvements.

3.2.3. Implementation of the governance

Communication tools

The communication tools are part of the guifi.net model: an email mailing list for communication, periodic meetings for settlement of the compensation tables, and a web reporting tool to collect expenditure reports.

Participation framework

CPRs must be properly managed to avoid depletion [28]. The governance tools presented in Figure 3.1, a refinement of the one presented in [1], are the result of more than a decade of theoretical and practical work. Generally, the improvements in the governance system have been introduced in response to specific challenges as they appeared. Figure 3.2 presents the most relevant threats and needs faced over time, their context, and the governance tools developed in response to them. Tools

and methodologies are under constant revision in an open and participative process chaired by the Guifi.net Foundation.

The *Licence* [55] (forming the lower layer of the governance tools (Figure 2)) is mandatory for participation and also sets the legal foundation for the development of the rest of the governance tools. The participants who use a significant amount of resources from the CPR are obliged to sign an *agreement for economic activities and for the participation in the compensation system* [56] with the Foundation[15]. This agreement obligates the participants to take part in the *compensation table* of the scope in which they operate. The compensation tables are regular meetings aimed at establishing the criteria for periodic *compensation settlements*.

Agreement for economic activities and the participation in the compensation system

The agreement for economic activities and the participation in the compensation system agreement is a legally enforceable contract that establishes the rules for participation of those cases that require regulation beyond licence such as installers, operators, investors, public administrations, etc. It formally defines the foreseen roles, the activities that entail the obligation to sign a compensation agreement, the scope, and the participation guidelines. The essential excerpts of the document are quoted in [57].

Compensation settlements

The compensation settlements are aimed at ensuring i) a fair distribution of the network operation costs based on use of the resources and ii) the generation of the required resources to recover the investments made or to enable future ones. The compensations are implemented by balancing between the contributions or the expenses of each participant and its use of the CPR. The balances are calculated by periodically applying the current compensation criteria. The resulting amounts are settled between the Foundation and each participant either in cash in the case of the installers or by placing them as an accounting entry to a bank account held by the Foundation (the so called compensation buckets) in the case of the operators (i.e., those who have recurring income). In the latter case, if the resulting amount is negative, the participants must make a deposit to settle it; if it is positive, they can use the funds to reinvest according to their needs or interests.

Table 3.1 presents a simplified compensation settlement with five participants and the Foundation, which is always present because it plays the management role. The columns present each participant's contribution, its consumption, and its balance, in absolute terms and in percentage. The contributions and the balances are in terms of money. The consumptions are measured according to the criteria established in the corresponding compensation table, in terabytes of a given port of a specific router in this example case. The balance percentage is reached by subtracting the consumption from the contribution and the absolute term is arrived by multiplying the balance percentage by the total contribution. Participants 1, 2, and 3 have both contributions and consumptions, which is the typical case for operators that extend or maintain the network and simultaneously use it to deliver their services. Participant 4 only declares contributions but not consumptions and therefore is either a pure maintainer or an investor. In contrast, Participant 5 just has consumptions, which indicates that, in this compensation table, Participant 5 is the only one using the existing network as a means of transport of its services, thus, it is acting as a pure operator. The contributions declared by the Foundation at least include the management costs of this compensation table.

[15] In any governance system that is intended to be fair, the governance mechanisms must be driven by organisations without any conflict of interest, and mechanisms for the participation of individuals must be put in place.

	Contribution		Consumption		Balance	
	EUR	%	TB	%	%	EUR
Participant 1	300	30	4.5	45	-15	-150
Participant 2	250	25	1	10	15	150
Participant 3	150	15	1.5	15	0	0
Participant 4	250	25	0	0	25	250
Participant 5	0	0	3	30	-30	-300
Foundation	50	5	0	0	5	50
TOTAL	**1000**	**100**	**10**	**100**	**0**	**0**

Table 3.1: Demonstrative compensation settlement.

Revenue split and accounting

In order to ensure that the operators charge the reinvestment quantities agreed in the corresponding compensation tables to their customers and to increase the overall transparency, all the operators must issue their bills using a standardised model in which the contributions to the CPR are explicitly stated as i) contribution to the deployment of infrastructure or ii) contribution to its maintenance (currently 17€ + 6€ for optical fibre customers and 4€ + 4€ for WiFi customers, respectively).

In each billing cycle (monthly), the operators must provide the list of the amounts per customer they have collected to the Foundation. The Foundation uses this data to i) calculate the compensation settlements of the next compensation cycle, ii) ensure that the operators are properly reinvesting these funds by cross-comparing these lists with the expenses they have declared through the expenditures declaration system and other sources of information, and iii) issue the donation certificates to the end users, where appropriate (according to Spanish regulation, a contribution to the commons infrastructure is a donation; thus, the donors (i.e. the customers of the operators) may benefit from a tax deduction).

Governance tools

The specific participation framework just defined provide tools for a sustainable governance of guifi.net involving professional participants in a given area. These target two areas: a) Conflict resolution, and b) Economic compensation, to compensate for imbalances between investment in the commons infrastructure and network usage.

3.2.4. Services provided

The main service provided in the different compensation tables of guifi.net (in each geographic scope) is the compensation service to ensure the maintenance and sustainability of the network infrastructure commons.

3.2.5. Implementation of the infrastructure and impact

In this section, we will present some of the results from the implementation of the compensation tables in four regions: two started in 2014, Osona and Lluçanès, and two in 2015, Bages and Vallès Oriental.

Quantitative results

The accuracy of the monitoring and reporting systems necessary to operate the compensation tables entails vast amounts of data, which, in turn, produce some interesting results. The results presented here are aimed at showing the level of detail that can be obtained. Nevertheless, these results are valuable by themselves because they quantify some parameters essential for the network operation that, thus far, were estimated with very limited data sets at best. All the data are publicly available on the Guifi.net website.

Table 3.2 links the accumulated number of nodes and the expenditures declared in 2014 and 2015 of the wireless network. Taking into account the small variation between the number of nodes, which means that the capital expenditures (CAPEX) can be neglected, we may conclude that the EUR/node/month rate shown corresponds to the operational costs (OPEX). This analysis shows that, roughly, the OPEX of a rural zone, Lluçanès, is double that of a semi-rural area, Osona.

Table	**Year**	**Nodes acc.**	**Expen. EUR**	**Expen./ /node/ /month**
Osona	2014	8,356	51,569	0.51
(from 01/14)	2015	8,978	49,779	0.46
Lluçanès	2014	1,069	9,079	0.85
(from 03/14)	2015	1,111	11,135	0.83
Bages Or.	2014	423	17,179	5.80
(from 6/14)	2015	536	8,849	1.37
Vallès Oriental	2014	-	-	-
(from 7/15)	2015	1,507	8,849	0.97

Table 3.2: Yearly expenditure per compensation table.

Qualitative results

The analysis of the data also produces qualitative results like the effectiveness assessment of a given measure, the identification of bad and good practices, the detection of errors and frauds, etc. For instance, we observe that, in all compensation tables, the first year accounts declared higher expenditures, while they have fewer nodes. This fact is partially attributable to the irrational perception that declaring more expenditures is beneficial for the person. This behaviour has the positive consequence of helping 'normalisation' (declaration of secret nodes, update of hardware description, etc.), but when taken to the extreme like in the Bages dispute case in 2014, a particularly acute conflict in that area that generated extreme tension putting the ecosystem at risk. Such situations can only be rectified through a combination of education, social skills, and technical expertise to accommodate the compensation system to the local circumstances.

The overall experience of applying the compensation system is entirely satisfactory since it has been key to settling entrenched disputes, reactivating investments, strengthening collaborations, unveiling and eradicating bad practices, etc. Concrete examples include the merger of two companies that were fighting each other to the point of putting the whole project at risk due to the amount of customers they had and the number of preparatory meetings to activate new compensation tables arranged recently. The feedback received has been used to improve and fine-tune the system and is the basis for future work.

Lessons Learned

This section discusses what, in our understanding, are the main lessons learned:

Scientific approach Solutions must be designed for a worst-case scenario, not based on expected collaborative attitudes. The Guifi case shows that ISPs tend to confuse accounting and cash flow concepts, such as those generated by the services they provide and those generated by the exploitation of the CPR that have reverted to them. Hence, a strict monitoring and continuous learning environment is required to ensure best practices and to avoid the risk of fraud-like deviation of the cash flow to private profits.

Formality During the early stages of the CPR bootstrapping process, where there is a reduced circle of confidence, trustworthiness and verbal agreements between partners may be sufficient. However, as the network grows larger and when multiple stakeholders with varied interests begin to participate, governance is a must to keep the networks truly open to all. It is mandatory to implement formal mechanisms that prevent exploitation of the CPR and its essential values. For example, preventing incumbents from being tempted to forget the principles that allowed them to grow in prosperity due to the collaborative environment since some beneficiaries of the network may start using the CPR for their own economic benefit.

Volunteers The compensation mechanisms do provide an effective way to put a value on their contributions; however, volunteers typically feel less legally bound to the project and may disregard or dislike accounting, paperwork, or procedures. Thus, the group must understand that a methodology and some metrics are needed for recognising results and reputation and that there is no way to claim contributions made without accounting for them first.

Minimum prices Customer fees must guarantee not only the reinvestment of cash flow but also the survival of the ISP itself. Hence, they cannot go below a certain threshold that may put the sustainability of any of the two at risk. The agreements on minimum prices made in the compensation tables must not be seen as a violation of the free market rules but as a strategy to ensure the sustainability of the ecosystem, as they help prevent bad practices, such as disinvestment and dumping.

Early adoption of the governance tools The governance tools were already mature enough to be adopted since the very beginning by new bootstrapping communities. The experience shows that late adoption is challenging and time-consuming, as it usually breaks implicit assumptions.

The compensation system we presented in this paper has been a key factor to enable and boost the sufficient economic activity in order to assure the required resources to maintain and extend the network. The data sets and the implementation of the compensation system allows systematic computation of crucial parameters that so far have been estimated just based on short data samples in the best cases.

There is still further work to do. The governance and methodologies described in this paper have not yet effectively been applied to all existing zones. In addition, optical fibre installations represent a significant shift from OPEX to investments on CAPEX. This makes the compensation mechanisms more complex; thus, this requires a continuous revision of criteria, simplification, better definition of targets, and refinement of the strategies to achieve them.

3.3. eXO association

The Association for the Expansion of Open Network (eXO) corresponds to a large part of the local guifi.net community in Barcelona. It exemplifies how a local community can organise and specialise

the guifi.net principles to manage a local network infrastructure with specific characteristics, a large urban area, in a sustainable way with the participation and economic contributions of volunteers and professionals. It exemplifies how the general principles of guifi.net can be adapted to local conditions and achieve good results. For that reason it is described in a separate section from the overall guifi.net network.

3.3.1. History and Principles

When the project Guifi.net came to Barcelona in 2007, in coordination to other existing local CNs such as Wireless Gràcia (GSF, in the Gracia neighbourhood) and many volunteers, a new open network structure was defined to include the city and surrounding municipalities. Seeing the need for coordination between the groups, organizations and individuals who were part of the project Guifi.net throughout the metropolitan area, the eXO association was created to support joint projects linked to the development of guifi.net in that area.

The eXO association is deeply rooted to the Guifi.net project and driven by the same principles. It cooperates with and contributes to the guifi.net Foundation. The eXO brings together communities, organizations, businesses and individuals to promote open, free and neutral telecommunications networks. Its aim is promoting knowledge of ICT technology, as well as promoting solidarity in user communities on a local and regional basis. It operates in the area of Barcelona and surrounding municipalities.

The main objectives are:

- Promote and encourage the development of open networks and infrastructure for information and communication.
- Promote and encourage universal right to communication and information, contributing to the reduction of the digital divide.
- Promote and encourage the development of open hardware and software to support the network and use applications sectors.
- Disseminate knowledge on ICT technology
- Train technicians, installers and companies to address to their connectivity needs.
- Collaborate with other groups and organizations to exchange knowledge and coordinate efforts.

Regarding the methodology, eXO is based on the model of the guifi.net network and it follows the same approach:

- Encourage, promote and support all initiatives of non-profit partners, seeking synergies between them and other groups.
- Find and create resources to promote the development objectives set.
- Definition and monitoring of projects and results evaluation meetings continuously.
- Real evaluation of projects marking qualitative and quantitative indicators before and after the project

3.3.2. Stakeholders

Most stakeholders are individual members, citizens interested in participating in the expansion and sustainability of the guifi.net infrastructure in Barcelona and its metropolitan area, understood in

several dimensions: technological, economic, social, cultural. There are also a few professional and academic members with additional and complementary interests.

3.3.3. Implementation of the governance

Participation framework

Members pay membership quotas to the association, and have a voting rights in the general assembly. Other than that, the association and its participants are subjected to the guifi.net general participation framework, and recently that also includes de participation framework of the compensation system.

Communication and coordination tools

Communication and coordination is supported by the usual set of tools: a weekly face-to-face community meeting (guifi-labs) taking place in about 4-5 different locations on different weeks, and digital tools for communication such as a member email list, an online chat, video-conferencing, wiki, network visualization and monitoring tools, and coordination tools such as those required the allocation of overlay tunnels for Internet access.

Governance tools

Regarding governance, the organization is membership based, with all of them being part of the general assembly and a few in the executive board elected every year. eXO is deliberative, all discussions happen in the mailing list or chat, are also discussed in weekly face-to-face meetings, and ratified in the yearly general assembly meeting. At the guifi.net level it also participates and uses the guifi.net governance tools, and recently also the compensation-related tools.

Sustainability

In the last period (2015) the budget from member contributions was 1,740 €. Roughly 50% of the budget was devoted to network upgrades for maintenance and expansion, 34% to maintenance, and the remaining 16% to reserve funds for future needs. eXO has joined the compensation table in Barcelona, together with a few professional participants, which implies a cost and expenditure audit and an exercise of transparency that contributes to the sustainability of guifi.net in the area of Barcelona.

3.3.4. Services provided

The main service eXO provides is the support and coordination to expand, maintain, manage the guifi.net network in the area. Other services are: Internet access (tunnels), training activities, servers (chat, video repository, proxies).

eXO organises meetings and training courses and sponsors several projects such as: IPv6 planning and deployment, coordination of WiFi coverage for events, coordination of participation in social activities (SONAR festival, Science week festival, Creative Commons festival, Solidarity Economy festival), coordination of the Sants Mesh network illustrated by Figure 3.6, coordination with industrial and academic research projects.

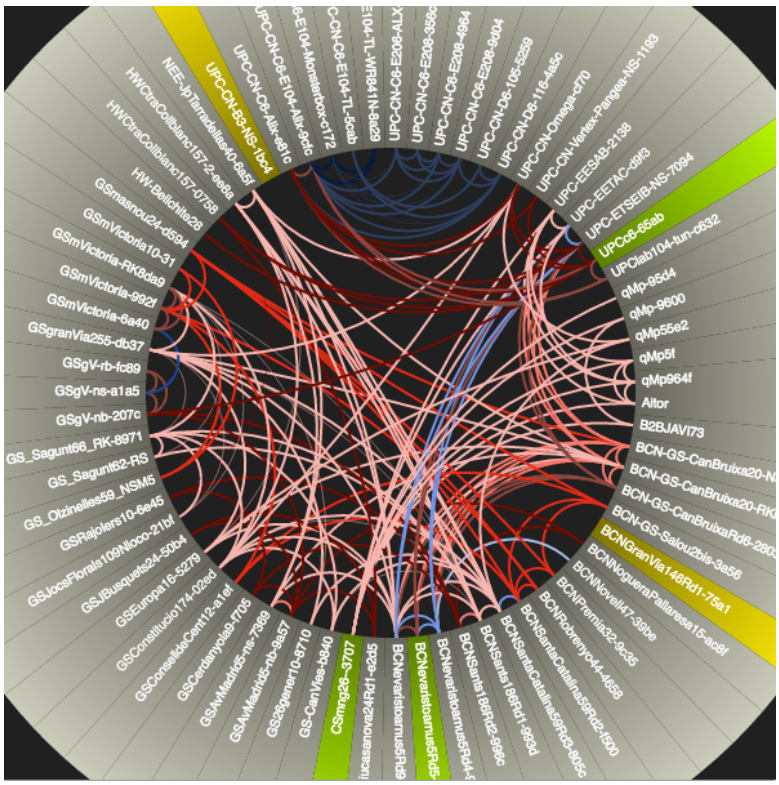

Figure 3.6: A network map of the Sants wireless mesh network supported by eXO

3.3.5. Implementation of the infrastructure and impact

The executive board has currently 7 members including a treasurer, secretary, president and deputy president. It has 52 active individual members in May 2016.

The main results are reflected by the evolution and sustainability of the guifi.net network in Barcelona. In an urban area, with its specific characteristics (e.g. dense apartment buildings, dense population, high level of spectrum usage and noise, lower social bounds than in rural areas), the wireless mesh model has been very successful. eXO has contributed to develop knowledge, experience, best practices, tools to manage, expand and maintain wireless mesh networks in several neighbourhoods in the area, with the largest example being the Sants area, currently with 71 nodes (see Figure 3.6), which corresponds to different apartment buildings, each with one or more households connected to each node. Another result is the provision of a community managed Internet access based on IP tunnels over the guifi.net network. eXO members share the price of a wholesale Internet connection bought from the guifi.net Foundation.

3.4. AWMN

3.4.1. History and principles

The Athens Wireless Metropolitan Network (AWMN) is a wireless CN that has been connecting people to broadband services ever since its first steps in 2002. The network's infrastructure is a Common Pool Resource (CPR) to which participants contribute their own efforts and goods (routers, links and servers).

The network was launched in 2002, in a time where ADSL connections were at a pilot stage and broadband access for residential users was almost non-existent. AWMN started with the initiative of a small group of people that were interested in the new technologies and particularly in wireless networks. They managed to create a metropolitan wireless network that allowed users to have fast symmetrical access. Shortly after its foundation, AMWN experienced a rise in the number of participants who quickly endorsed its open philosophy. At that time, AWMN evolved beyond an alternative telecommunications network to a social participatory one. One of the most important characteristics that played an important role in the network's evolution is the fact that its members are people of different ages that possess high educational level, i.e. students, professionals from the field of computers, networks, radio amateurs and lovers of technology.

AWMN consists of two basic parts: infrastructure and services. The infrastructure is expanded each time a new node is created. The nodes in the network use a variety of operating systems, with a clear preference for free software. The equipment uses the wireless standards IEEE802.11a/b/n and comes from various manufacturers, with dynamic routing protocols and a plurality of structures. The network's topology is described as a partial mesh and consists of two kinds of nodes *backbone* nodes and *client* nodes. Backbone nodes are the ones in charge for routing the network's data traffic and they can potentially (subject to each node owner's decision) become Access Point (APs) and as such serve client nodes. Clients nodes are nodes that can only be connected to the network through APs and they are basically terminal nodes i.e. consumers of connectivity and services. Currently, there are 1230 active backbone nodes and 874 APs. The services are mainly deployed by participant individuals or group initiatives and have developed greatly over the years. The educational level of AWMN members has played a significant role in the development of local AWMN services. The vast variety includes communication services, data and information exchange services and entertainment services.

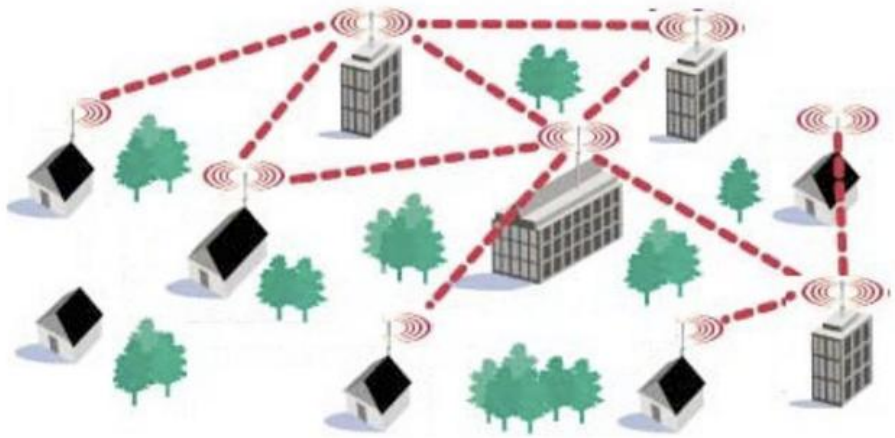

Figure 3.7: AWMN partial mesh topology.

3.4.2. Stakeholders

The Association of AWMN: The Association of AWMN is the legal representation of the network. According to its establishment rules, the Association of AWMN is characterized as non-profit, open, plural and participative and its role is supportive to the network. Externally, it reflects the presence and visibility of the network to third parties, i.e. public local authorities, organizations, other associations, universities and research institutes and engages to potential

cooperation efforts that contribute to the expansion of the network. It also organizes assemblies, training seminars and workshops with the goal to educate anyone interested in the use of wireless and digital communications. Internally, it is responsible for the maintenance of central services and network management. Part of its objectives is to collect contributions, common funds and equipment, with the purpose of using them for the benefit of the network and its members. Assemblies that are organized by the Association for AWMN members have multiple benefits. Apart from knowledge exchange they strengthen member relations', promote cooperation, volunteerism and active participation.

The number of AWMN Association members is unlimited. The participation in the Association entity is voluntary and is not subject to gender discrimination. Any interested node owner has the right to apply and become part of the Association. Interested members can fill out an application form expressing their interest to participate and should be proposed by two existing members of the Association in the assembly. The Association then decides on the inclusion of the new member.

According to the official Association rules (published in the AWMN wiki) its goals are briefly described as:

1. Establish, develop and maintain a community wireless network connecting people and services in the metropolitan area of Athens.
2. Develop wireless digital telecommunication technologies.
3. Train people in the usage of wireless technology digital telecommunications.
4. Inform the public as well as promote and disseminate wireless digital communication technologies.
5. Represent users of the community to government authorities and regulatory organizations.
6. Inform the Greek and the Global Community on the potential and capabilities of wireless broadband services in the metropolitan area of Athens.
7. Promote the idea of providing broadband symmetrical digital telecommunication services, non-profit, in cooperation with local authorities, organizations, associations, university and research institutions.

It should be stated that some of the members of the AWMN community do not acknowledge the existence of the Association[16]. In August of 2010, the Association counted 67 members (the lowest number from its creation). However, there were about 900 backbone node. Owners denied to participate in the Association questioning transparency and speech censorship practised in the association's forum, wiki and assembly.

Volunteers: Volunteers are the basis of AWMN. There exist many forms of volunteering within the network. Once new users decide to join AWMN, they acquire the necessary equipment at their own expenses, install it at their homes and become part of the network. Backbone nodes expand the network and route traffic. In this way, backbone node owners are both consumers and producers of connectivity. On the contrary, client node owners are not involved in routing and only consume connectivity (or services). Indicative of the community sense of the network's participants, is the fact that many members develop applications or tools and share them with the rest of the network. It is also usual for members, to voluntarily form task groups and confront different network matters ranging from service provision to solving technical problems.

[16] https://en.wikipedia.org/wiki/Athens_Wireless_Metropolitan_Network

Volunteers also offer donations and economic contributions for the operation and maintenance of the network.

Third parties: Third parties include educational institutions, associations, local administrations, independent regulators, NGOs, wireless communities and any other entity that cooperates with AWMN aiming at the expansion and development of wireless technologies. One such example, is the collaboration of AWMN with the Greek FOSS society, which resulted in new AP installations that provided access in public spaces around the city (i.e., schools and squares). Another is the participation of AWMN members in the CONFINE project. This collaboration led to installations, which formed part of the network infrastructure for experimental purposes (Community Lab testbed [58]).

3.4.3. Implementation of the governance

Communication and coordination tools

The widespread distribution of the network infrastructure has resulted in the development of a variety of tools that promote participants' interaction.

Website: One of the main coordination and information tools is the website of AWMN[17]. This is basically a centralized tool that provides access to other tools such as blogs, online chat, user groups, VoIP tools, mail servers and network monitoring tools. Through the AWMN portal users can access the community's forums, where they arrange their meetings, exchange information about the network's technical issues and technological challenges, provide help and information to newcomers. Users navigating on the website can contribute economically and offer their donations to the network via crowdfunding. The website of AWMN is publicly visible but registration is a prerequisite for accessing special features such as posting in forums and some of its services.

Wiki: The Wikipedia of AWMN[18] concentrates theoretical and empirical knowledge with how-to guides, steps and settings to follow for accessing the variety of services, self-construction hints, technology specifications, legal matters regarding the laws relevant to telecommunications infrastructure and operation, rights and liabilities in the use of the network and safety rules for infrastructure implementation.

Mail servers: The network provides local mailing services[19], where each user can get his own AWMN mail address and communicate with other members within the network. It facilitates the use for mailing lists and exchange of information.

Face to face meetings: The members of AWMN schedule face-to-face meetings, workshops and seminars for exchanging knowledge, sharing experiences, discussing about network issues and solutions, meeting and guiding new interested members and making the operation of AWMN visible to the public.

Participation framework

Participation in the network is open (everyone has the right to know how it is built) and free for anyone who wants to join (non-discriminatory principle). The steps for someone who wants to access

[17] http://www.awmn.net
[18] http://www.awmn.net/wiki
[19] https://mail.awmn.net/zimbra/

the network include: a) creating an entry for the new node in the WiND system (described in the next section) to position it and find nodes within line of sight (LoS); b) studying and understanding the basic concepts of wireless networking and AWMN from the free guides located in the AWMN website; c) announcing the intention to join the network to the community of AWMN; and d) buying and installing the equipment needed with the voluntary assistance of experienced members. There is no legal framework needed to participate in the network. No one is obliged to sign a peering agreement or join the Association of AWMN in order to participate in the network. However, node owners are obliged to keep their nodes in a good shape for the smooth operation of the network and follow the rules of the community and net neutrality.

Network management and provisioning tools

Some of the most common tools used by AWMN members to monitor the statistics of the network include:

Wireless Nodes Database (WiND): WiND[20] is an online database of nodes that allows for their dynamic registration and management. It depicts existing active nodes, nodes to be connected to the wireless network in a map representation (Google Maps) and individual node information. The WiND project has been developed by members of AWMN in an effort to cover the needs of node management within the network. Practically, it replaced the previous database NodeDB i.e. a closed source project that did not allow for changes in the code. On the contrary, WiND is an open source project. It supports Google Maps, Google Earth with kml files and nodes are represented in the map based on their individual node labels. WiND incorporates a calculator for the LoS between two nodes, a calculator of geographical coordinates, allows for exchanging messages through an internal mail service, bilingual support (greek and english), quick node search, co-management of nodes, record keeping of network services, IP and DNS addressing and cross checking connections (for a connection to be verified it need to be acknowledged by both sides).

Nagios: Nagios[21] is an open source tool used for monitoring the network's backbone with dynamic alerts from arts of the network that experience troubleshooting. The tool also facilitates the retrieval of network statistics regarding traffic, usage, problems etc.

Cacti Graphs: Cacti graphs[22] is an open source network monitoring and graphing tool used by AWMN members to observe the status of the network. It permits the storage of all the necessary network information and provides an insight with flexible settings and graph creation.

Network WeatherMap: Network WeatherMap[23] is an open source tool that allows for creating live network maps using acquired data information.

Governance tools

The management of the network is carried out by several groups that have been developed formally by the Association groups and informally by voluntary user initiatives. According to the AWMN Association rules, the following acting governance tools. Apart from the Association of AWMN mentioned in 3.4.2 the rest of the government tools include:

[20] https://wind.awmn.net
[21] https://www.nagios.org
[22] http://www.cacti.net
[23] https://network-weathermap.com

The General Assembly: The General Assembly is the governing tool of the Association. The General Assembly, in particular: a) elects the Administration Board, the Audit Committee and the Disciplinary Committee, b) decides on the approval of the Budget and Report and the Annual Board, c) amends or supplements the Association rules and their interpretation d) supervises the work and activities of the Board and the Auditing Committee. e) decides on the change of purpose, the dissolution of the association, and the expulsion of a member due to important reasons. In total, there are two types of General Assemblies, one regular at the beginning of each year and one urgent called upon when there is a timely significant matter to be discussed. The General Assembly decisions are taken by majority of half plus one of the members, by showing of hands, unless a request for a secret ballot or otherwise take a decision at least 10 members.

Administration board: It is a five member group with a two year service. It is elected by universal suffrage from the members General Assembly within the first 3 months of every second calendar year. Along with the five elected members of the board, three more deputy members are elected in order of merit to assist the work of the Board in cases that the elected members face some kind of difficulty in their duties. The five elected members perform an extra voting to decide on the President, the two Vice Presidents, the Secretary, the Material Superintendent and the Treasurer.

Audit Committee: It is a three-member committee with two-year term and two deputies. Its work is subject to the Law provisions and corresponds to monitoring and controlling the financial management of the Board.

Disciplinary Committee: It is a three-member disciplinary committee with two-year term, whose task is to decide on disciplinary penalties for the members of the Association.

Tech groups: AWMN sets up different groups to confront different issues of the network depending on their skills and preferences. Such groups are:

Admins: This is a group with a two-year term that manages the security and maintenance of the servers and the services of the Association.

Hostmasters: This is a group focused on functionalities such as domain name addressing, IPs and management of WiND.

Forum Moderators: They are the moderators of the official AWMN forum.

Other groups: Task groups can be formed ad hoc depending on the services provided. We also find groups focused on routing, VoIP etc.

3.4.4. Services provided

The services are shared among network members and are categorized as follows:

Communication services: Communication services are deployed to assist the communication between community members. Local VoIP telephony, user and community forums, mail service and instant messaging applications such as the Internet Relay Chat (IRC) come under this category.

Data exchange services: . Network users are able to exchange files with P2P file sharing and FTP servers, access video, image and audio galleries and local cloud services.

Entertainment services: Entertainment services include a variety of multi-player games, broadcast services with live streaming i.e. audio and video streaming, workshop and event broadcasting and radio stations.

Information and education services: AWMN users are able to follow online seminars via e-learning, get informed in community wikis, follow the weather, find the information using local search engines (i.e., Quicksearch, Wahoo, Woogle) or even develop texts using collaborative writing services. The discovery and use of services is facilitated by sites that provide centralized services.

Internet service: AMWN members clarify that access to the Internet is not a service provided by the network itself but is up to the node owner's will to share their internet connections.

3.4.5. Implementation of the infrastructure and impact

The impact of AWMN can be traced through figures regarding the number of active nodes, number of available services and the geographical coverage of the network.

After 14 years of existence, the numerical expansion of AWMN can still be considered notable [59]. According to the WiND tool, there are currently 2342 active nodes out of the 12562 nodes which were developed ever since its beginning, 1300 of which are backbone nodes, with 2575 links overall. The number of active APs that allow the connection of clients are 874 and there are in total 732 active services over the 798 that have been deployed over the years within the network. As depicted in Figure 3.8 the network's backbone nodes keep increasing over the years. However, in the past 4 years the growth happens at a much lower rate.

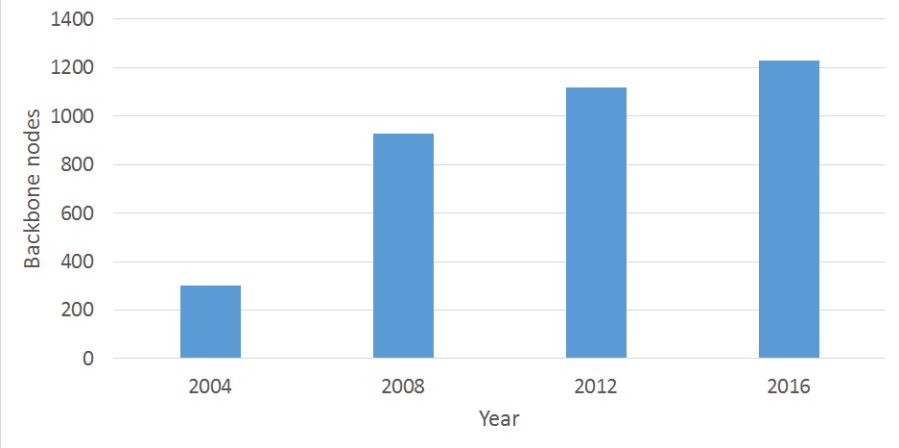

Figure 3.8: AWMN growth in number of backbone nodes.

The geographical coverage of the network is extended over several urban areas of Attica, including several public places (schools, squares, refugee camps). There also exist connections (physical or VPN) to smaller wireless networks all over Greece i.e. Sarantaporo.gr, Thessaloniki Wireless Metropolitan Network (TWMN), Evia Wireless Network (EWN). Outside Greece, AWMN contains VPN connections to several European wireless communities i.e. Guifi.net, WLAN Ljubljana, Funk-Feuer.

The development of AWMN has been based primarily upon the initiatives and cooperative spirit of its members. AWMN members have contributed and shared their technical knowledge and experience with other network members and third parties interested in learning through the organization of events, workshops and assemblies. This type of cooperation and knowledge sharing creates positive effects for the participants. They enhance their technical skills in ways that can benefit their professional activities and job search. Through their involvement in AWMN, its members have also been able

to experience and develop cooperation principles in practice generating added social value for the community as a whole [29]. The impact of AWMN on other communities is also evidence in the help and support that network members have provided in the creation and development of smaller wireless networks in other parts of Greece. One indicative example is the consulting and sharing of technical expertise for the formation of Sarantaporo.gr. In conclusion, either through its own deployment of infrastructure and services or via assisting the deployment of other wireless networks in the rural area of Greece, the AWMN has brought many people in contact with broadband services.

3.5. FFDN

This section presents FFDN,[24] the umbrella organization for 28 community networks (CNs) operating across France (plus one in Brussels, Belgium).

For this initial study of FFDN, CNRS built on fieldwork conducted prior to netCommons [60], legal analysis of bylaws and other founding documents, observant-participation during FFDN's yearly General Assembly (on May 7-9th 2016 near Grenoble, France), as well as subsequent online interviews.

3.5.1. History and Principles

FFDN was founded in 2011. At the time, the most visible community network was FDN, founded in 1992 when most Internet access providers were non-profit entities. After many events impacting the digital rights debate and in which its leaders took part (e. g., WikiLeaks Cablegate, of the Arab Spring, important debates on copyright enforcement like ACTA or SOPA), FDN's president Benjamin Bayart and other FDN active volunteers motivated people across France to join and start building their own community networks. Rather than growing a single organization, or even the handful of other community networks already existing across France at the time, the choice was made to "swarm" in a decentralized mode by creating many local non-profit organizations, all under the French 1901 law on the freedom of association.

To coordinate these developments, share expertise and organize the legal and political representation of the movement, an umbrella non-profit organization was also created: The *Fédération FDN* (or FFDN). It now comprises 29 member organizations[25] operating in both rural and urban areas, using both wireless and leased landline networks, whose (physical) members are automatically members of FFDN. They all adhere to values of collaboration, openness and support of human rights (freedom of expression, privacy) embedded by the Free Software Movement. FFDN and its member organizations also reflects a specific political culture, a citizen sociality tied to France's "vie associative." This makes for a very diverse community of CNs in geographical, technical as well as socio-political terms (as a participant to the 2016 GA put it, "some [of us] work in suits, other don't work at all").

FFDN's principles are laid out in three important texts that provide a framework for corresponding practices: its bylaws[26], its internal rules[27] (*règlement intérieur*) and its Charter of good practices and common commitments[28], which defines the notion of "(*associatif*) Internet service providers." FDN CNs "shall not use commercial methods, such as for instance the purchase of advertising space."

[24] https://www.ffdn.org/.
[25] https://www.ffdn.org/en/members-fdn-federation
[26] https://www.ffdn.org/en/members-fdn-federation
[27] https://www.ffdn.org/fr/reglement-interieur
[28] https://www.ffdn.org/fr/charte

People sitting on the boards of FFDN's CNs must be unpaid volunteers and earning must be "systematically kept on the books or reinvested." The Charter also requires members to commit to "protecting and/or promoting the Internet" and Net neutrality. These concepts are FFDN's own way of framing Internet networks as a commons.[29]

The following presentation of FFDN's organizational elements considers FFDN as a whole but focuses on five its member organizations most representative of the whole spectrum of governance, economic and technical models found in the federation:

FDN FDN (French Data Network) is the historical French CN, founded in 1992. Providing ADSL connectivity at a national scale on last-mile landline infrastructures leased from incumbent operator Orange (either through partial unbundling through the proxy of another major telecom operator, SFR, or directly through non-unbundled access with Orange). FDN has 502 members, about 330 of which are also subscribers.

Scani Scani (former PCLight) was founded in 1998, first as a *association*. It is now evolving towards the status of a cooperative (*Société coopérative d'intérêt collectif* or SCIC, a status for business and employment cooperatives created in 2001[30]). Scani is particularly interesting: not only is it the first venture of an FFDN member to include professional organizations including a few paid employees (rather than active volunteers); it is also the first FFDN member to foray into the deployment of last-mile fiber optic connectivity.

Faimaison Created in Nantes in 2011 with the help of FDN, Faimaison started by providing ADSL connections and is now moving to expanding its network with WiFi links. Still small (about 80 members of which 15 are subscribers). It is very active on the advocacy front, organizing social events around digital rights campaigns led by French or European NGOs.

Tetaneutral.net Tetaneutral.net is a wireless community network founded in 2011. Its starting goal was to provide Internet access rivalling commercial Asymmetric Digital Subscriber Line (ADSL) offers that, in certain parts of the city, were limited to 512K. Its coverage soon expanded to half a dozen rural areas in the surroundings of Toulouse that previously did not have access to a decent broadband connection. After 5 years of existence, Tetaneutral.net now counts almost 500 members, including 400 subscribers.

Rézine Rézine is based in Grenoble and was founded in early 2012 and though smaller, is similar to Tetaneutral.net. It provides a mix of ADSL and WiFi Internet connectivity in Grenoble. It is also interested in accessing a public radio network developed by local authorities in the district of *Isère*, but is still looking for interested potential subscribers to make the operation financially viable. It currently has 57 members, of which 43 are also subscribers.

3.5.2. Stakeholders

Member organizations FFDN's first stakeholders are its non-profit *member organizations* (the *associations* that join the community's umbrella entity). They are required by FFDN's internal rule to be registered as telecom operators before the French NRA. Other legal persons such as businesses, which share FFDN's values and goals and wish to take part in FFDN's activities cannot be members but the bylaws include a "correspondent" status for joint action (correspondents do not have the right to vote).

[29] On FFDN's commons framing, see also section 3.5.5.

[30] https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=JORFTEXT000000757800

Core volunteers Core volunteers include both FFDN's *core volunteers*, including its board members, who usually have leading positions within one or several member CNs, as well as the active volunteers of member organizations (FFDN's CNs). Core volunteers take an active part in the strategic discussions held on the future of the organization, and gather the technical and regulatory know-how necessary to the operation of member organizations.

Members The second circle of stakeholders comprises all of the close to 2500 official *members* of FFDN's member organizations (membership fees are usually around 15€ a year). Among these, about 40% do not subscribe to any of services provided by CNs (for technical or practical reasons), but have nevertheless decided to adhere to these organizations out of political conviction on the importance of community ISPs. Besides these *non-subscribing members*, 1500 members are *subscribers* to one or several of FFDN CN's services (you have to be a member of a FFDN CN to subscribe to its services). Most of these subscribing members are not active volunteers and may subscribe to FFDN CNs out of political conviction, without taking an active part in its operation or governance. Others include residents in rural or suburban "white spaces" deprived of decent Internet connection, who choose FFDN's members because there is simply no better alternative[31]. Finally, some are motivated to subscribe by the technical thrill of managing their own Internet connection in cooperation with other like-minded individuals.

Partner organizations A third category of stakeholders includes partner organizations such as a handful of small-and medium businesses, which are member-subscribers of FFDN CNs, *social projects* (other *associations*, squats, protest groups) and *public administrations* that subscribe to (or use the free) service provided by FFDN members because they offer a flexible and/or cheap solution to their needs. For instance, in Toulouse, Tetaneutral.net has been working with small villages in rural areas close to the city to bring high speed connections to villagers. In one instance, the city council gave Tetaneutral.net access to a pole in order to install an antenna. In exchange, Tetaneutral.net brought a high speed Internet access to the village's elementary school. Tetaneutral.net has also been working with a clinic specialized in providing healthcare to homeless people, many of which are migrants, so that they could video-chat with their families back in their home countries[32]. Scani has also been working with a mayor and member of Parliament Jean-Yves Caullet in the district of *L'Yonne* to help bring broadband Internet access to local residents after commercial operators had declined to do so.

3.5.3. Implementation of the governance

Network and provisioning tools

The software tools for network management and provisioning are the following:

Network map tool Since 2014, a group of FFDN sysadmins worked from scratch to develop a Wifi mapping and networking monitoring tool. Called Wifi-with-me[33], it helps map out the best

[31] This can also happen in city centers. For instance, in Toulouse, in contrast to commercial alternatives, whose speeds are less than 1 Mbps in some parts of town, Tetaneutral.net brings 30Mbps symmetric connections (to be shared between several users).

[32] The clinic gives its patients free Internet access, but used to rely on the commercial subscription of the hospital to which it is attached. That 40Mbps connection was being shared between hundreds of staff and patients, thus forcing the hospital's technology officer to restrict Internet communications: Along with other bandwidth-intensive protocols or applications, online video-conferencing was blocked. By working with Tetaneutral.net, the clinic was able to easily set up an independent broadband wireless Internet access and lift traffic restrictions.

[33] See https://code.ffdn.org/ffdn/wifi-with-me.

positions for antennas, what links are technically possible to build. Other mapping tools are used to map landline connections based on subscribers' ZIP code. Scani has a more developed tool that also gives details about subscribers' contact, billing as well as technical information. It works but the code has yet to be cleaned for use by other FFDN members. Tetaneutral.net has a similar home-made tool. Usually, mapping information is accessible to all members through a private section of the organization's website (but not to the public for obvious privacy reasons).

IPs assignment and routing configuration For IP assignment, FDN wrote its own piece of code for an automatized and web-facing system administration: COIN[34]. Other core volunteers use more ad-hoc methods like based on command-line and MySQL databases. In one case, on an university campus, subscribers were able to directly manage their IP assignment.

Network monitoring Other sysadmyn tools include Nagios. Nagios Core, is a free software application that monitors systems, networks and infrastructure. It ensures the proper functioning of, switches, applications and services. It alerts users when things go wrong and alerts them a second time when the problem has been resolved. Principally aimed at core volunteers, some of information like types of currently running service are broadcast to members so they can can all see if network problems are likely to be the cause of potential issues with their connection.

Network crowd funding At FDN, crowd funding takes the form of donations or financial advances (typically by members/subscribers) to pay for the cost of initial equipment and for the development of the network. Other sources of funding include donations, subscriptions fees, and at least in one case a small project-based subsidy from a local authority (FDN, on the contrary, makes a point of refusing any public subvention). Ilico called for donations by local inhabitants to start connecting its first nodes in rural *Corrèze*. Most of the time, especially for WiFi networks, network equipment is owned by the community rather than by subscribers.

Expenditures declaration and accountability In terms of accounting, whether it relates to expenses or equipment costs, fees or other revenue sources, all items are typically publicly made available to anyone. Tetaneutral.net, for instance, sends out monthly emails to its mailing-list describing the current number of fee-paying members, subscribers and associated revenues, recent investment in equipment as well as changes in the network infrastructure. These e-mails are publicly available through the "transparency" section of the organization's website.[35] However, many other FFDN CNs are only offering transparency on accounting to their members –which anyway is an obligation that comes with the 1901 law. Most of them use the free software DOLIBARR to do so, but some have developed their own home-made tools.

Communication tools

Websites All FFDN member organizations have websites where they present the organizations. Except for a handful of them, these websites are often poorly designed and cannot be described as particularly engaging (for instance for complete newcomers who would be interested in learning about or joining a community network). At a minimum, the common values shared by FFDN members (Net neutrality, freedom of expression, privacy) are usually mentioned in the "About page", information is given on the CN's main activities, and basic contact information is provided. Websites like Tetaneutral's, though minimalist in design, offer direct access to many information.

[34] https://code.ffdn.org/FFDN/coin/.

[35] For an example of such an e-mail, see Tetaneutral.net's financial state of play for June 2016: https://lists.tetaneutral.net/pipermail/tetaneutral/2016-June/000665.html.

Wikis If websites are usually poorly maintainted, wiki platforms are used much more extensively by many FFDN CNs for documenting and coordinating the group's activities, giving members direct access to the organizations important documents (bylaws, minutes of Gas, etc.).

Mailing lists Virtually all members-organizations have their own mailing-lists. FFDN has one mailing list for all the members of its CNs where major issues or decisions are presented and debated, one for the board. Some mailing-lists are created for specific working groups (on regulatory or technical issues).[36]

IRC channels FFDN has a public IRC channel on Geeknode (#ffdn) with an average of 150 participants daily, as do most of its member CNs (Tetaneutral.net IRC channel on Geeknode has about 130 participants). IRC is where most of daily interactions, coordination and debates between FFDN's members happen.

Redmine Several FFDN CNS use Redmine to coordinate working tasks among active volunteers.

Twitter accounts Most FFDN members CNs and active volunteers have Twitter accounts.

Participation framework

All FFDN members have been created as *associations* under the Law of July 1st 1901 on the freedom of association.[37] The law ensures the non-lucrative purpose of the organization and enforces basic democratic rules regarding its functioning. The status of "*association loi 1901*" is used by millions of non-profit organizations active in community life across France.

Principles of democratic governance are also enshrined in FFDN's founding documents, and in particular the Charter. The latter posits that every member of FFDN's CNs must have the right to vote during General Assembly, where board members are elected, accounting is audited and major decisions are taken.

Ad hoc do-ocracy In the vein, of Free Software communities in which many FFDN participants are socialized, the group works often as a "do-ocracy", in which individuals choose roles and tasks for themselves and execute them. A member's recent interest in boosting the activity of the group in the field of telecom regulation resulted in many discussions being held at the 2016 GA on the matter and to the creation of a dedicated working group with its own mailing lists. People interested in developing the Internet cube similarly got together and carried the project autonomously.

Growing through sharing As many other CNs across the world, FFDN's member organizations hold regular events to sustain a feeling of community and facilitate knowledge-sharing, on technical topics such as setting up a radio antenna to experimenting with the latest innovations in DYI self-hosting. Active volunteers help newcomers to set-up and use their Internet connection.

In spite of the lack of engaging communications tools that would help FFDN CNs reach new subscribers and active volunteers, the Charter claims that FFDN members "shall provide information to public authorities and the general public on the Internet and its functioning, as well as the stakes associated with its development." Members must also assist any *association* willing to become CNs by providing technical assistance and helping out with "scarce resources" like A.S. or IP addresses.

[36] See the list and short description of the 16 mailing-lists of FFDN at the following address: https://lists.ffdn.org/wws/lists

[37] *Loi du 1er juillet 1901 relative au contrat d'association* https://www.legifrance.gouv.fr/affichTexte.do?cidTexte=LEGITEXT000006069570&dateTexte=20090506.

Network Commons License FFDN's Charter on good practices and common commitments lists the duties of its member organizations. FFDN ISPs commit for instance to provide a public and routable IP address (preferably static) to each subscriber. Member organizations also have to provide a domain name or subdomain to subscribers making a demand to that effect. Another requirement relate to the principle of network neutrality, i.e., the fact that ISPs shall not "impair in any way the data transmitted on behalf of subscribers, without the consent of the affected subscriber." The Charter further makes clear that the service provider "shall not modify the content of the exchanged messages (...)." In the same spirit, the "ISP shall make no judgement on the relevance or significance of a data stream on behalf of the subscribers," and shall not filter (by blocking specific content) the Internet access of its subscribers, except in case of legal obligations (in which case these obligations as well as the technical means used to comply with them shall be fully transparent).

Reference Authority The FFDN Charter requires that member organizations provide legal representation to their members to fulfil their common goals as laid out in the Charter and bylaws. Some member organization with legal difficulties (judicial or administrative request for a subscribers identifying information, or copyright takedown requests for material hosted on their servers) have consulted with volunteer legal experts for legal advice. A legal team called *Les Exégètes amateurs* has been put together by France's digital right advocacy group La Quadrature du Net, FDN and FFDN. In the future, it should be able to provide a form of legal consulting to FFDN's members.

Collaboration agreements Solidarity and collaborations is a key objective for FFDN and in practice are an important driver of material support between FFDN members, as more established information help newcomers by giving or lending by giving or lending resources like IP addresses, AS, equipment, servers, cheaper bandwidth, etc. It is conducted more on an *ad hoc* basis than on agreements, even though it is also mandated by the FFDN charter.

Governance tools

Conflict resolution system and economic compensations system According to FFDN leaders, the fact that it is a volunteer-run organization explains why there is no real need for formalized conflict resolution or economic compensation systems. However, the arrival of professional for-profit members in FFDN could provide the incentive to develop such governance tools.

Tax Issues related to tax have also surfaced, since organizations like FDN, which operates on a national basis, have been subject to business taxes and VAT. The fiscal services granted that FDN was an "*association* with disinterested management", but one that had a "commercial activity" and which therefore should pay the same taxes as their mainstream business "competitors."

3.5.4. Services provided

FFDN's CNs provide the following services, either at cost price or with a small profit margin aimed at ensuring investment capabilities.

Internet connectivity Except for 7 out of 29 member organizations, all FFDN's CNs provide Internet connectivity (with a static IP address) to their 1500 subscribing members, often for a fee ranging from free price at Tetaneutral.net (20€ suggested, radio equipment being provided for

free), 15€ at Rézine, 30-40€ for ADSL at Faimaison (cheaper when the connection is unbundled) and 29-40€ at FDN (all prices here are per month). 13 of FFDN CNs including FDN and Faimaison lease landline networks to incumbent operators to provide access to their subscribers. 8 others deploy wireless networks connected to the Internet through an uplink provided by telecom operators operating on the B2B sector (e.g., Cogent) but often combine this radio networks supporting up to three WiFi channels with Fiber To The Home (FTTH) access contracted with incumbent operators to offload subscribers' traffic.

VPN 7 CNs offer only VPN service to their member-subscribers. In such cases, subscribers need to have their own traditional Internet access service. What the CN provides is basically an encrypted tunnel routing the subscriber's traffic to one of their VPN servers, along with a static IP address which can immunize a subscriber against its incumbent provider's technical restrictions (for instance, Orange banning the use of port 25 on ADSL offers and therefore preventing a user from running a mail server at home).

Self-hosting About 5 CNs, including Tetaneutral, offer hosting services, making room in a squat or a data-center, where the organization's servers are based, for members to install their own servers. Hosting a small machine such as laptop, a NAS or Raspberry Pi costs 5 to 10 euros at Tetaneutral, or 17€ at Faimaison.

Virtual Machines FDN and Faimaison provide subscriptions to a service offering access to Virtual Machines hosted on the CNs' servers.

Internet cube An important technical project carried on by the FFDN community in the past years is the "Brique Internet" (or Internet cube), a small device to be plugged to one's Internet box. It provides a WiFi hotspot channeled to FFDN member's VPN service and embarking a Debian-based self-hosting OS called Yunohost, which runs a mail server and embarks platforms like Ownclou+d or a PirateBox for local file-sharing.[38] 8 FFDNs CNs currently distribute the Internet cubes configured with a VPN access they provide, for a price of about 65€ per unity (plus the monthly cost of the VPN subscription).

BitTorrent Tracker A team of volunteers close to members of the FFDN have set up some of the biggest BitTorrent Tracker, torrent.eu.org, freely used by tens of thousands users daily.

IndéCP Tetaneutral.net and other FFDN volunteers have assisted a national network of 42 independent movie theaters in setting up an online distribution system for digital copies of films[39].

3.5.5. Implementation of the infrastructure and impact

FFDN has successfully structured and expanded the number of communities operating CNs across France. In spite of their very small number of subscribers (around 1500), they have had fantastic results of some its members in helping bridge the digital divide in several rural communities. A few partnerships have been sealed with city councils which, in spite of France's relatively good broadband penetration, were underserved by incumbent operators. Since the creation of federation in 2011, tens of thousands of Euros have been spent by its members to roll-out a citizen-owned and/or citizen-managed network.

FFDN core volunteers have become telecom experts (some of them participate in research on computer science) and their capacity in articulating the techno-political stakes associated with digital

[38] See https://internetcu.be/ and https://yunohost.org.
[39] http://www.indecp.org/

telecommunications has ensured their status as an influential "citizen voice" in national policy discussions on issues such as network neutrality.

FFDN represents an interesting model because –and as opposed to Freifunk or Ninux– it combines local autonomy with a collective institutional framework for loose coordination and legal representation (similarly to guifi.net but in a more flexible and decentralized fashion overall).

That being said, it remains to be seen if it can be sustained on the longer run. FFDN faces issues associated with any volunteer-based organizations: Finding the time and the appropriate resources to provide better service to its members, streamline governance mechanisms, organize public events and develop strategies to recruit new active volunteers and participants. In what follows we summarize some of the challenges identified based on our preliminary fieldwork, highlighting some specific features of FFDN compared with CNs in other countries.

Leadership FFDN is undergoing tensions due to the prominent role of the FFDN founder, Benjamin Bayart. He and many others insisted on the necessity to develop more horizontality in the operation of the organization and better share knowledge, in particular on telecom regulation. More generally, there seems to be a lot of strain put on few active volunteers (often the initiators) who do the bulk of the work necessary for the operation of the organization. In a least a couple of instances, FFDN CN have put their activities on hold due to lack of active volunteers.

Recruiting new participants While issues of diversity and horizontality are discussed, there seem to be little collective reflection about *strategies* that should be developed to recruit more member-subscribers, member-participants and active volunteers to make existing CNs more resilient and maximize their impact locally and at the national level. It is as if FFDN –still being in a foundational phase– preferred to grow organically.

Growing existing CNs and seeding new ones Correspondingly, there is little strategy on how to seed new CNs or even to ensure the expansion and sustainability of existing ones. However, during the GA, the recently announced French plan for fiber roll-out –and the promise of many "fiber orphans" that this disappointing plan entails– was seen as an avenue for seeding new CNs in underserved areas. It remains to be seen how FFDN can develop and implement a strategy in this respect. Its rather distant relationship to businesses (even though many of its active participants work in the IT sector) may also be a factor precluding a faster growth rate, especially when seen in the light of the Guifi.net model.

Regulatory challenges Regulatory challenges are numerous and the subject of many discussions within FFDN. During the GA, fascinating discussions were held over the legal obligations of Internet access providers operating open WiFi hotspots, in particular on issues such as data retention were significant legal uncertainties remain. Other topics of interest included the upcoming European consultation on Net Neutrality guidelines, the transposition of the EU Radio Directive, access to airwaves, and more generally the need to be proactive in trying to influence telecom regulation. The issue of regulatory capture —the fact that the French NRA, the Arcep is under undue influence of incumbent operators, in particular by France Telecom/Orange– was also raised as an issue. That being said during the GA, Bayart and a prominent member of FDN working with him on regulatory issues stress the fact that many within the NRA are very keen on receiving their comments, which often contrast with the oft-repeated and mostly unsurprising material they get from traditional players in the telecom market. Sometimes, Arcep officers directly call leading FFDN members to ask them to participate in their consultation, although with little significant results overall.

Political issues v. the Commons Relatively to other CNs, political and legal issues seem very important for FFDN participants in general, and its leadership in particular, relatively to tech-

nical issues. Conversely, there is little reflection on the notion of commons, though virtually all participants would also think of themselves as free software supporters and contributors (their activity as CNs is often framed by using concepts coming from FLOSS: trust, "four freedoms," etc.). From FFDN's member's websites and exchanges at the GA, the idea of social inclusion is very present. There is reminiscence of Commons theory but more indirectly than what one would probably observe in other CNs. The way they frame their activity is often in relation to Net neutrality and other issues of trust and security tied to digital rights and free software activism (which can be explained by the influence of advocacy organizations in providing a political frame for their activity as CNs, whereas in other countries, that "political frame" may come from other milieus, e.g. more closely tied to cooperativism and the commons movement).

3.6. Ninux

3.6.1. History and Principles

The Ninux Community Network is one the oldest CN in Europe. It was bootstrapped in the early 2000s in the city of Rome, in which still today there is the majority of the network nodes. Ninux uses a completely decentralized and horizontal approach. The community is not formalized in any organization, and its initial spirit was mainly targeted at experimentation and hacker culture. The name of the network , "Ninux", stands for "No Internet, Network Under eXperiment".

Since the Ninux CN is a non-structured community there is not a single source of information. Each Ninux community (or Ninux "island" as the Ninuxers say) is run by an independent group of people. As such, mining and organizing the information about the network is a complex task. In this report we include the information extracted from the analysis of the main communication instruments. The technical analysis performed on the mesh network and direct inquiry to the participants of the community. We follow the structure introduced in section 2 to describe Ninux.

3.6.2. Stakeholders

Ninux is run by volunteers. Each of them runs one or more than one node, participates to the meetings and is active in the promotion and advocacy for the network. There is no formal umbrella Ninux association, but there is no rule that prevents a Ninux island to create one. Each member has to agree on the Ninux manifesto, that is a variation of the pico-peering agreement adopted by other European CNs. The manifesto states only some basic principles among which free transit, open access, and best-effort approach (no guaranteed service level) [40].

Each member of the community is invited to join the community, present him/herself and be active, but no formal engagement is required and no identification is requested. In principle, a person that has enough technical skills and wishes to enter the network, can set-up his/her own node, attach to the network and never communicate in person with the existent members.

3.6.3. Implementation of governance

Communication Tools

The main communication tools used by Ninux are the following ones.

[40] http://wiki.ninux.org/Manifesto

Mailing Lists: every island has its own mailing list, created on request by the participants. There is also one national mailing list for generic discussions on the themes related with Ninux and side-topics.

"contatti" email alias: this is an email alias that is used as the public interface towards the exterior. Emails sent to "contatti@ninux.org" are received by a subset of the participants of the Ninux community, that answer to the sender based on internal discussion. The people aliased in *contatti* use the alias also to discuss among them on the answers to give. This email has been created to give an official entry point to interested people and to give answers in a more mediated way, compared to the mailing lists, in which anybody can answer to the newcomers. People enter in the alias list upon request from somebody that is already included, and after an internal discussion. In some cases this inclusion process has sparkled some controversy, as it has been perceived as an "inner circle" of people taking decisions for the whole community.

Website: the main website of Ninux is a Wiki, collaboratively realized by the community[41]. Some of the pages are translated in English, but the language is primarily Italian.

Blog: the community also has a blog[42], a Wordpress website where the community writes aperiodically on topics of common interest.

Face-to-face meetings: each island organizes periodic meeting with the local community. From time to time a national meeting is organized, the last one was in 2013, the next one is scheduled for 2016.

The Mapserver: the mapserver is a key instrument in the Ninux community, because it represents the entry point and the monitoring instrument of the community. We describe it in more details in the following of this section.

The mapserver[43] contains a geo-located map of the current state of the network. The mapserver is updated periodically by a software that is configured to load all the topologies from the various Ninux islands: each island publishes a topology file at a public URL using one of the supported formats, and the active nodes and links can be visualized in the map. As said, it is not only a public mirror of the state of the network, but it is also a fundamental instrument for new users that want to enter the network, that can use it to find other nodes nearby, compute an approximated distance and contact the owner of existent or potential nodes in order to set-up a new link.

The mapserver was developed by the Ninux community, it is powered by an open source platform named "nodeshot" available on github. A new version of the mapserver is under development[44]. The new version takes into account the growth of the network and its organization into islands and adds useful tools such as the visualization of the altitude profile between two points in the map, to check the possibility of having line-of-sight connections.

Participation framework

To enter the Ninux network the procedure that is suggested by the community for the newcomer is the following:

1. Present him/herself to the community, via the general mailing lists or the specific island-based mailing lists;

[41] http://ninux.org
[42] http://blog.ninux.org
[43] http://map.ninux.org
[44] http://map.nodeshot.org

2. Create a "potential node" in the Ninux mapserver corresponding to a place where he/she can physically place a network node. A potential node is a new placeholder in the network map, that anybody can create and represents an expression of will to enter the community. To create a potential node the new member is requested to register with an email account. In the potential node description he/she is invited to describe briefly the characteristic of this new potential installation, such as the height of the building and the possibility to access the roof. New members are also invited to take pictures from the place where they intend to place their antenna and publish them in another section of the website;
3. The new member is invited to join one of the face-to-face meetings that Ninux islands organize. The frequency of such meetings depends on the specific island. In the most lively islands they are typically held weekly, or bi-weekly;
4. Via the mapserver, the new member can find the existent, or potential nodes that are likely to be in communication range with his potential node. Once such nodes are identified the owners can be contacted in person or directly via the mapserver. The presence of pictures helps to identify if there is line-of-sight to one of the existent nodes;
5. Once identified the possibility of creating a new node connected to some other existent node, the new member will be guided in the process of acquiring the necessary hardware, re-flashing the firmware and mounting the node. This procedure is guided with practical documentation and how-tos that the community has been producing since its beginning, and by the voluntary efforts of the participants.

Ninux leaves to the member of the community the freedom to choose any software or hardware instrument that he/she feels more comfortable with, with a strong bias on free, open-source software. The Rome island uses Optimized Link State Routing Protocol (OLSR) and is today testing the next version, Optimized Link State Routing Protocol version 2 (OLSRv2). This gave some bias to the other islands such as the Florence islands, but there are other islands that use different routing protocols, such as Batman advanced. There is a Virtual Private Network (VPN) that, if requested by each island, can connect the islands one to other, using broadband connections made available from the participants.

Even if there is no structured entity, some Ninux users take the responsibility for some services that would not be possible to achieve in a collective, non-structured way. Among these:

- The management of the domain name "ninux.org";
- The registration of an Autonomous System, number 197835;
- The connection of the Rome Ninux Island to the NAMEX, the neutral access point of Rome;
- The management of a set of public IP addresses. These are assigned to members upon request and can be located in some existing nodes and accessed from outside the network via the existent gateways. The gateways are placed in Rome but can be used also via the VPN from other islands.

The technical realization of a node is, again, left to the decision of the users. One configuration that is suggested by the community is the "ground routing" configuration. In such configuration the radio devices (which are, in reality, full-fledged wireless outdoor routers, but are referred to as "radios" for simplicity) act as Layer-2 bridges, connected via cable with the ground router (in some cases, as reported in node-A in Figure 3.9 to a roof switch, that is then connected with only one cable to the ground router).

This configuration implicitly solves one organizational problem, that is the convergence on hardware and software platforms, as well as some legal and commercial implication on the use of re-flashed

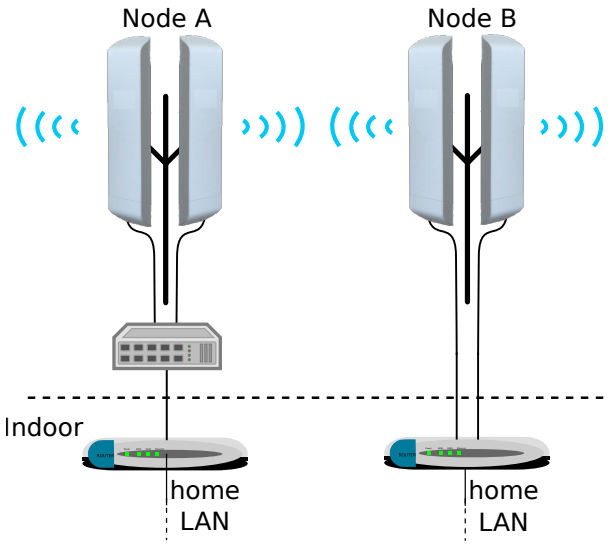

Figure 3.9: A wireless node configured for ground routing.

radio hardware. As for the former, with ground routing, the routing function resides in a device placed in the user's house. This device can be any device, a wireless router, a normal PC or a low-power embedded device (like a Raspberry Pi device). The radios instead, can be kept with the original firmware, and simply configured to act as bridges, relaying the traffic, basically unmodified, to the ground router. This configuration is flexible enough to allow many kinds of users to cooperate. The most skilled users, that have experience in choosing and configuring devices will choose the radio they prefer, while the others will simply leave the stock firmware on the radios. This flexibility makes it possible to run the network without converging on a single hardware/software configuration, which is a difficult process in a community made of hackers with different background and experiences. This is one example of technical solutions that allow to overcome (to some extent) the need for complex community management. Ninux does not have a decision-taking system, decisions are taken via consensus in the mailing lists, and in some cases controversies arise. Using flexible technical solutions that allow different sensibilities to cooperate (in this case, people inclined for the use of proprietary software, or open source software) helps avoiding energy-consuming controversies.

The latter implication is on the legal field, since there are national and European laws that define the emission limits and the use of Dynamic Frequency Selection (DFS) on specific Industrial Scientific Medical (ISM) frequencies. The use of the stock firmware allows the inexperienced user to stay on the safe side without any additional configuration needed.

3.6.4. Services provided

The focus of Ninux is on the internal services of the network, it is not on Internet access. The community has a strong commitment to give this message to the newcomers, that are often attracted by the idea of a free internet access but neglect the communitarian aspects of Ninux. Ninuxers tend to discourage new members whose only interest is to access the Internet at a lower price than the price offered by commercial ISPs. This does not mean that there is no Internet access from Ninux, but it is delegated to the decision of each Ninux island and it is not sponsored as the main feature of the network. In some cases local ISPs give to Ninux users free access to the Internet but this is not the feature that the Ninux community puts its focus on.

3.6.5. Implementation of the infrastructure and impact

Ninux is a Wi-Fi mesh network, implemented with standard wireless router equipped with custom firmware. The Ninux network is composed of several islands spread around the Italian peninsula. Being an informal community, it is hard to define the impact of Ninux: Ninux does not have "users", it does not have aggregated bandwidth statistics, it is impossible to estimate the CAPEX or OPEX of the infrastructure. Some tangible achievements that can be attributed to Ninux are the following ones.

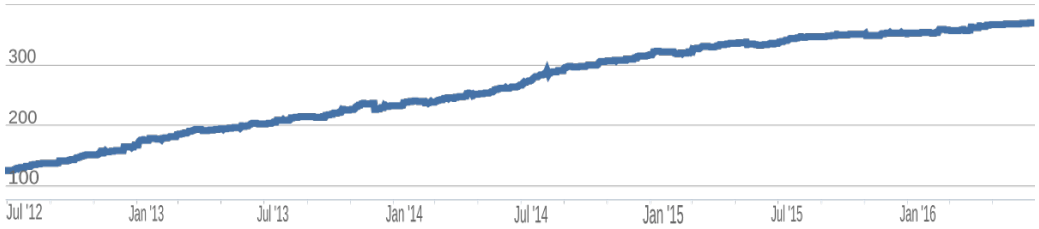

Figure 3.10: The growth of the Ninux network in the last 4 years: June 2012 - June 2016.

Size and growth: according to the statistics present in the mapserver, Ninux is currently made of 372 nodes. About 170 are concentrated in the Rome area, where the network was born, and the rest are distributed in much smaller islands (the largest one counting 30 nodes) spread around Italy. The growth of Ninux in the last few years was constant and visible, as reported in figure 3.10.

Visibility: Ninux has received attention from mainstream newspapers in the latest few years, probably due to a mix of factors, among which the attention to privacy raised by the Snowden affair. This has increased the visibility of the network and contributed to the definition of its image to the exterior. A collection of press articles dealing with Ninux is present in the wiki[45].

Projects: the Ninux infrastructure was included in the CONFINE project testbed, the FP7 FIRE project that opened the way for research on community networks.

NAMEX connection: Ninux is connected to the Rome Neutral Access Point (NAMEX), via a dedicated device placed on the NAMEX building roof. The connection was possible since the statute of NAMEX allows this kind of experimentation. Being connected to NAMEX gives Ninux visibility and in the future it may allow to set-up peering agreements with other ISPs connected to the NAMEX.

Internal services: it is not easy to map the services that are available on Ninux, since each island has its own services and the lists of available services are not always updated. Among them we mention content sharing (local clouds and backups), personal communications (chats, videoconferences), collaboration tools (git repositories, etherpads) etc.

The NetJSON format: every community network uses its homegrown instrument to visualize and manage the network, with specific features required by the community and incompatible with the others. The NetJSON format[46] is an attempt to unify at least the description of the network, in order to be able to exchange the state of the topology and some other related information. NetJSON is an initiative started in the Ninux community that generated an experimental RFC,

[45] http://wiki.ninux.org/Stampa(inItalian)
[46] http://netjson.org

today several routing protocols implementations support the export of their topology in NetJSON, in order to be able to be collected and analysed with a unique instrument.

3.7. Sarantaporo.gr

3.7.1. History and principles

Sarantaporo.gr is a CN, which connects 14 villages through a common telecommunication infrastructure and provides access to its network services. It is located in the rural area of Elassona, in the north-western part of Greece. The poor access to basic telecommunication services due to non-existing network infrastructure stood as the main motivation for the development of this CN. Due to the geographic location and small population of the villages, network operators had not invested in the area until quite recently. Hence, the locals did not have access to the Internet and subsequent services that are dependent on ICT technologies. The core team of Sarantaporo.gr launched its activities in 2010. A group of people got together on a voluntary basis and started creating a wireless CN that provides access to broadband services for local residents, local institutions, groups and visitors of the area. Network equipment was first installed in the Sarantaporo village; gradually, nearby villages followed with the help and cooperation of active local residents and communities. The initial deployment was financed by the Greek Free Open Source Software (FOSS) society, for the access network (160 access nodes), and later by the EU project CONFINE, for the backbone (21 backbone nodes). There were also cases where individuals set up their own nodes to become part of the network. Until recently (August 2016), the funding of the network operation and maintenance was under the responsibility (and good will) of local cultural organisations. This scheme proved inefficient in terms of liability, punctuality and transparency. Today, according to the new sustainability strategy of the network, each node holder contributes financially with an annual fixed sum, which is gathered from all the end users of the node.

The network Sarantaporo.gr is characterized as public, open and social in the sense that:

- It is implemented and developed by the core team in collaboration with local groups, partners and active residents of the area;
- It is open and free to use for any resident, entity or visitor of these areas, as long as the use is in accordance with the operation rules of the network;
- No profit is incurred from the access to the network.
- The network users contribute to its sustainability in a collective manner.

Sarantaporo.gr is a promising alternative for rapidly bridging the digital divide in remote areas of the country most in need, while promoting cooperation and equal participation in the digital age and its wealth of knowledge and opportunities. From its very beginning, its goal has been to boost the socio-economic development of this under-served agricultural area and create the conditions needed for cooperation of all relevant stakeholders.

3.7.2. Stakeholders

Non-profit civil partnership: Sarantaporo.gr has been established as a non-profit company in 2013. It is the legal entity behind the network. The partnership is composed of a group of people, who were active since 2010, plus additional members who were interested in joining the effort over time. The partnership follows a set of articles of the organization and is subject

to the Greek legal framework about NPOs. Any change in the membership (i.e., additions or withdrawals of members), can be made according to the prescriptions of the corresponding legislation for NPOs and the organization's statute. The core team meetings take place periodically using online tools and the decision-making process is participatory and consensus-based. The overall approach regarding the management of the network adheres to do-ocracy principles .

Volunteers: The volunteers involved in the network can be local support groups, individuals or associations that offer their help and services in preserving and extending the network infrastructure and may also contribute financially via donations.

The local groups refer to local cultural associations or any kind of group formed within the village with the objective of collaborating with Sarantaporo.gr core team. Part of their role involves collecting donations to cover the annual operational and expansion network costs. Their contribution is also critical in identifying and reporting situations of network failure.

The body of volunteers also includes few individuals who are eager to contribute time and effort to the network. Some also contribute to the financial targets of the organization (e.g., 60€/year per access point) by donating money. Nevertheless, most people using the network do so contributing neither effort nor funds (free riding).

Public organizations: Public organizations and institutions have been involved in the network in various ways:

- The Greek FOSS society has provided the network with the majority of the initial equipment for building the separate access networks within the villages through the Open Wifi action.
- The Technological Educational Institute (TEI) of Thessaly is a partner that gives access to its infrastructure and provides Sarantaporo.gr with Internet access, which is currently one of the network's most appealing services.
- The local municipality of Elassona has given permission to use a small warehouse in the antenna park in a mountain near Elassona to place some of the network's telecommunications equipment.
- Finally, Sarantaporo.gr has received support from EU through its participation in the EU project CONFINE, through which it funded the creation of the network's backbone.

Professionals: These are companies or small businesses that provide services over the network. The integration of professionals in the network is a fairly recent idea. There are examples of companies that can provide VoIP services and sensor monitoring and have Sarantaporo.gr users as customers. These market-oriented activities are yet at an early stage but the collaboration with more companies and their integration in the network is part of the partnership's future plans.

3.7.3. Implementation of the governance

Communication and coordination tools

These communication tools facilitate information exchange and interaction of all involved entities of the network and interaction within and outside the network.

Website: The main tool that users can access and get informed about Sarantaporo.gr is the website. The website bears a strong community aspect in the sense that it is not only a way to follow

the updates, events and status of the network itself but it also includes news and information of the community as a whole such as recent news, historical information about the villages that compose the network, local sports, cultural associations, geographical guides, weather forecast etc. The website can be accessed both locally by connecting to Sarantaporo.gr and globally via the Internet[47]. Information about the backbone and local network architecture is publicly accessible via the website as well.

Social media: Sarantaporo.gr news can be found in social media through its presence in Facebook[48], Twitter [49] and YouTube[50]. The information shared in social media is public to all and facilitates interaction with people who are interested in the Sarantaporo.gr and wish to get informed, offer their support or participate. A special Facebook group has been created for people involved in the network.

Crowdfunding platforms: Crowdfunding plays a significant role in Sarantaporo.gr NPO as its operation greatly depends on volunteer contributions. It is another way of interacting with the broader public. The core team of Sarantaporo.gr NPO has recently assisted and supported a campaign, which used the Goteo platform to fund a documentary about wireless CNs that came true after the contributions of 88 participants within and outside Greece[51].

Other online tools: Regarding the coordination of the partnership and governance of the network, the core team of Sarantaporo.gr NPO uses online tools (e.g. Google hangouts, Doodle, Skype) to schedule and perform online meetings, facilitate the participatory decision making process, and foster transparency in the handling of internal economics.

Seminars: The partnership of Sarantaporo.gr often organizes educational and cultural activities in the broader area of Sarantaporo village and other parts of Greece to inform and train people in the use of CNs.

Network management and provisioning tools

Wireless Nodes Database: The nodes of the backbone network can be monitored through the Wireless Nodes Database (WiND), which provides information about the distribution of nodes, their activity or inactivity, and the status of links, as well as information about node connectivity and IP addressing management. Analytics tools used for the backbone network are Nagios and aircontrol. The equipment used for its deployment is Ubiquity [52].

Analytics tool: The local mesh networks (access networks) per village can be followed in real time by the Sarantaporo.gr website, which has incorporated the Cloudtrax controlling and monitoring tool of Open Mesh. The tool provides statistical information per node and is used by the Sarantaporo.gr team to monitor the status and usage of the network, such as the number of users accessing the networks and the volumes of traffic transferred through them.

Community Lab: Sarantaporo.gr participated in the EU CONFINE project, where a community network testbed was implemented. The status of the 18 backbone nodes, which form part of the testbed, can be accessed by the Community Lab webpage[53]. These mini servers (NUC devices)

[47] http://www.sarantaporo.gr/
[48] https://www.facebook.com/Sarantaporo.gr
[49] https://twitter.com/Sarantaporogr
[50] https://www.youtube.com/user/sarantaporogr
[51] https://en.goteo.org/project/building-communities-of-commons
[52] http://wind.sarantaporo.gr/?page=nodes
[53] https://community-lab.net/

are used for running the CONFINE firmware and hosting other Virtual Machines (VMs) as well.

3.7.4. Services provided

Sarantaporo.gr has been deployed over a remote agricultural area that faces different kinds of problems: poor access to infrastructure and equipment; physical distance from large cities; high prices for raw materials in the primary sector due to lack of information; unawareness of agricultural market demand. Services and tools provided by the network can help the locals to deal with some of the aforementioned problems. The types of services that can be found in Sarantaporo.gr at the moment are the following.

Internet access: This is one of the most popular services among the local residents. People get access to a wide range of internet services not only for entertainment purposes and socializing but also for crucial matters regarding their professional needs. Agricultural producers can now search for low-price raw materials, technical equipment, buyers for their products, information about their production and current state of market demand. Before the deployment of Sarantaporo.gr, the access to such available information was limited and their purchases where made through a few local intermediaries who could exploit their monopoly at the expense of the producers' profits.

Private VoIP service: Private VoIP service is implemented using private IP numbers. This is mainly used by the Sarantaporo.gr core team for the time being and facilitates their communication in organizing and managing the network.

Video streaming: Video streaming of important community events can be used on demand and in collaboration with the core team of the network. Video streaming can also be used for tutoring or training people in the use of ICT technologies.

At the same time, effort is made to develop the following additional services:

Monitoring: Locals may use monitoring tools for their farms or local businesses or weather monitoring. The cost of moving frequently towards a place of interest and the time needed can both be very high. Having the choice to monitor a place or the weather in a place via the network can save professionals and producers from spending valuable time and economic resources. A meteorological station has already been installed in Sarantaporo village for this purpose.

Large-scale VoIP communication: This is aimed for the network users and is to be provided in collaboration with the Modulus VoIP provider. By using large-scale VoIP communication, users will be able to communicate everywhere under the coverage of Sarantaporo.gr, without bearing the cost or the lack of coverage of traditional telecommunication operators.

3.7.5. Implementation of the infrastructure and impact

The Sarantaporo.gr core team has created and been operating a modern telecommunication infrastructure that is open to the local communities. The impact of the network can be seen through both quantitative data relating to the growth of the network and qualitative indices about people's everyday lives.

Quantitative data report currently 14 villages as connected to the Sarantaporo.gr network, with 21 nodes installed in the backbone network and 160 nodes (153 active at the time) in the access network. The network currently serves an approximate amount of 5,000 people, who are permanent residents,

and 3,000 more people who access it more occasionally. The amount of traffic moved around the network reaches 5.5TB on average per month and the maximum speed of network access is 30Mbps for download and upload links. 14 local support teams have been created thus far, totalling approximately 60 participants.

The impact of the network can also be observed through benefits it has brought to the community. Sarantaporo.gr has enabled the access to digital services in an area that was previously under-served. The network access provides people with the ability to participate in the digital economy and information society, practically mitigating the phenomenon of the digital divide. The initiative of Sarantaporo.gr could be considered as a contribution to the obligations of the Greek state to provide broadband Internet connectivity of at least 30Mbs download to all citizens by 2020, according to European Union Broadband Europe objectives for 2020. Moreover, prior to the construction of the network, the services of the local authorities were not accessible by all people in the area and the local municipalities faced complaints about the lack of infrastructure and connectivity. Now, the local authorities have a direct way of communication with the citizens and the citizens themselves are given an opportunity to get informed and participate in community matters. At the same time, the access to digital services opens up new opportunities for the implementation of useful services, such as telemedicine and tele-education, as well as the sharing of professional knowledge and experience that offer significant potential savings to human, economic and environmental resources.

The Sarantaporo.gr core team in collaboration with the Medical School of the University of Thessaly implemented two online questionnaires to investigate the risk of developing Obstructive Sleep Apnea-Hypopnea Syndrome (OSA) and Chronic obstructive pulmonary disease (COPD) in people of all ages, which led to free health-related tests (60 people) in the villages. Electronic prescription of medicines has also become possible through the use of the network. Before Sarantaporo.gr emerged, the prescription of medicines had been a challenging issue due to the great number of elderly people and their difficulty to move from the villages to the nearest town. Local businesses and professionals (i.e. farmers, breeder, shop owners) benefit as well. They have the opportunity to improve their work, discover new markets and new suppliers, and enhance their knowledge in the engaging subject of their work. Local residents benefit directly and their distant relatives indirectly since they are able to communicate regularly and in various manners. The locals and especially the young people have access to information, education, training, job searching, socializing and entertainment. In this way, the isolation due to the geographic location of the villages has been partially confined by the use of ICT. To this end, Sarantaporo.gr core team has been in collaboration with communities such as the "Unmonastery" group, who are working with locals in the sector of local development.

Future plans involve the expansion of the network to all 60 villages in the greater Elassona municipality with 24,758 permanent residents so that more people have access to network services and can benefit from its use while adding to its expansion. The aim is to deploy local services for the wide range of network users and provide them with the corresponding training. Moreover, the Sarantaporo.gr core team aspires to further develop its business model for the Sarantaporo.gr but with a framework generic enough to be made applicable to other similar under-served areas as well. Members of the core team are in contact with research institutions, universities, organizations and companies to explore new ways of collaboration aiming at actions of common interest that have impact on the local population.

3.8. Freifunk

3.8.1. History and principles

Freifunk is part of the history of CNs in Europe, which started through a series of key events organized in Berlin in the years 1999-2006 such as the "Wizards Of Os"[54], within which the "OLSR-Experiment"[55] started, and many artists, activists and tech enthusiasts in Europe were brought in contact around the concept. These interactions resulted, among others, to the Pico Peering Agreement[56] that provided the basis for most of the licensing schemes followed by different CNs around the world. As documented by Armin Medosch [61], "In September 2003 the first Freifunk Summer Convention FC03 happened in Berlin at c-base. This self-organised memorable event, from September 12 to 14, brought together a range of people and skills which gave some key impulses to the movement to build the network commons." [57]

The first antenna of the network was placed at the housing association project of one of the founders, Jürgen Neumann[58], the well-known K9 project at Berlin's Friedrichshain neighbourhood[59]. The practical reason was simply the need for Internet connectivity that was not so easy to get those years in the east part of Berlin. But the place where this first antenna was installed is a highly political place and Freifunk was always a political and social project, and still is. One can read today on the Freifunk web site, that "The freifunk community is part of a global movement for free infrastructure and open frequencies. Our vision is the democratization of the media through free networks. Free wireless communities implement this idea worldwide."[60]

Freifunk is indeed very clear in its basic principles of a community network:

- Publicly and anonymously accessible
- Non-commercial and uncensored
- Decentralized and in the possession of a community

Differently than the case of guifi.net, which places significant focus on the concept of "commons" implying concrete boundaries and resource management rules, Freifunk conceives community networks as an open to everyone space.

Many Freifunk members are also very active in developing core technology for CNs. There are many inventions in this area coming from Freifunk (Berlin) such as OLSR improvements (fish eye, ETX), BATMAN (Batman-adv and BMX), horst (a wireless sniffing and airtime analysis tool), and more.

Recently Freifunk experienced a sudden growth, from a few thousands nodes until 2013, to over 40,000 today, and still growing[61]. This was partly because of the improved software and reduced hardware costs that have facilitated significantly the node installation process, on the one hand, and the economic and refugee crisis, on the other. Especially in the case of Berlin, the Berlin Backbone has also contributed to the increase of the capacity and performance of the network.

This came also with some new challenges and tensions inside the network. For example, the non-profit organization which until then was mostly responsible for the dissemination of the ideas behind

[54] http://wizards-of-os.org/
[55] http://www.wizards-of-os.org/programm/specials/olsr_network_experiment.html
[56] http://www.picopeer.net/PPA-en.shtml
[57] http://www.thenextlayer.org/node/1285
[58] https://www.junes.eu/ppa/
[59] http://www.kinzig9.de/
[60] https://freifunk.net/en/what-is-it-about/
[61] https://www.freifunk-karte.de/#stats

the network had to deal with a significant fund of 30K to build infrastructure that should be necessarily owned by a legal entity. Despite the complete economic transparency[62], this is still a new situation for a community that worked for many years as a purely non-hierarchical and non-commercial organization.

Another "centralization" element of the network is the VPN service (see Sect. 3.8.4) that ensures that there are no legal consequences from Internet access sharing, which today is concentrated in a handful of servers.

However, these are considered by the Freifunk people only as temporary situations and there is a continuous process of finding solutions that can keep the network as decentralized as possible. The new German law on liability and the finalization of the MABB grant provide already a new ground for the right decisions along this direction.

3.8.2. Stakeholders

Freifunk has a deliberately flat organisational structure. It follows a quite clear schema of peer-production where all participants are volunteers, and the organisation is very decentralised and based on voluntarism. Public administrations or professionals have little or no formal interaction, and there are passive participants, consumers of the services provided by the CN.

The expansion of the network is purely decentralized and organic and the whole Freifunk network is mostly built out of voluntary contributions by each members, with the exception of the 30K grant received by MABB for the Berlin Backbone. But since the installation of a node does cost a non-neglible amount of money the Freifunk community relies significantly on political and social motivations to compensate for those costs.

3.8.3. Implementation of the governance

Communication and coordination tools

As in other communities, the technical skills of many participants has resulted in the development of many tools to facilitate internal and external communication, knowledge sharing, decision making and the coordination required to develop the infrastructure and the services it provides.

Public website: The Freifunk community has a common web portal that centralises access to common information and tools about the collective entity and providers pointers to each local community, with their own web site and communication tools.

Wiki: It constitutes a public repository of public knowledge about Freifunk.

Face to face meetings: local periodic meetings, like the c-base weekly meeting in Berlin, and the annual "Wireless Community Weekend"

The Freifunk API: [63] allows the individual Freifunk Communities, to publish their network topology and detailed additional information. Data is collected from a centralized server (or from anyone accessing it from the API website) and it is used to produce the maps of the network on the freifunk website.

[62] https://foerderverein.freie-netzwerke.de/wp-content/uploads/sites/3/2014/06/MABB_BBB_Abschlussbericht_2013_20140331.pdf

[63] API: http://api.freifunk.net

Network map tool: [64] provides a shared network map.

Mapping tool: for mobile devices [65].

Participation framework

Participation in the community is organized by a set of agreements: the peering agreements in the network infrastructure, the principles and goals to guide decisions, and an reference entity representing the community.

Pico Peering Agreement (PPA): The PPA defines the open principles of participation to the Freifunk network. In other words, *"the minimum baseline template for a peering agreement between owners of individual network nodes"* in which *''Owners of network nodes assert their right of ownership by declaring their willingness to donate the free exchange of data across their networks."*

Memorandum of Understanding (MOU): A new MOU was drafted on May 2015 to re-state the initial values of Freifunk in a moment of strong expansion of the network. Its text clearly expresses the core principles of freifunk: *"After 10 years Freifunk is quite successful, well known, and widespread. However we don't see that the original ideas and goals of Freifunk are still taken into consideration by all communities or all community members. It is not our intention to exclude communities which don't identify with this self-understanding. But we are interested in a basic discourse about what we are doing here jointly under the label Freifunk. This draft was written by a group associated with the Förderverein Freie Netzwerke e.V. It is meant to be a basic understanding and intends to encourage all communities to reflect on the stated topics: Why do we engage in Freifunk? Which ideas are behind it? Which goals do we pursue? According to which principles do we make decisions and take action? It is the goal of this text to develop an understanding which connects all individuals and groups who act under the label Freifunk."*[66].

Reference Authority: the Förderverein Freie Netzwerke e.V. All members of the Freifunk are welcome to join the corresponding non-profit organization, which is meant to require as little as possible (voluntary) effort and for this it has a relatively small number of regular members and a large circle of supporting members, which can all participate in the annual general meeting. The membership includes a fee of either 60 €(or more) per year to the Association's account with the intended purpose: annual contribution sponsor membership, Or the equivalent to 5 €(or more) per month with the purpose of: monthly fee sustaining membership[67].

Governance tools

Key persons: One can easily identify certain key figures behind the Freifunk network: Jürgen Neumann, Corinna "Elektra" Aichele, Sven Wagner, Monic Meisel, Phillip Borgers, Sven-Ola Tuecke, and others, but none of them assumes a special role in the network.

Freifunk association: called Förderverein freie Netzwerke e.V., is responsible mostly for fund raising and the operation of the main web site and other media platforms. As explained in the organization's web site *"The association focuses on the financial and moral support of projects*

[64] Network map tool: http://community.freifunk.net/
[65] Mapping tool: https://freifunk.net/blog/2013/10/neu-freifunk-app-fuer-ipad-und-iphone/
[66] https://github.com/freifunk/MoU/blob/master/FreifunkMemorandumofUnderstanding_en.md
[67] Membership: https://foerderverein.freie-netzwerke.de/mitgliedschaft/

to open and free communication infrastructures. The employees in the team and the Executive Board is honorary. It is financial and legal main carrier of the project freifunk.net, the campaign freifunkstattangst.de and other projects and sites of local Freifunk communities in Germany."[68]

Other activities of the association include the organization of events, like the International Summit for Community Wireless Networks Berlin 2013, participation in big conferences like the Battle of the Mesh and the Chaos Computer Club, running advocacy campaigns like the freifunkstattangst.de and the promotion of collaboration like the "freifunk @ Google Summer of Code"[69].

c-base gatherings: All important technical decisions are taken during the weekly gatherings at the c-base station, the headquarters of the well known German c-base cultural organization[70]. Meetings are open to everyone to the extend they can understand the technical language required. These meetings have been constantly organized since October 23, 2012, the first gathering at c-base a little after the "BerLon", a historic meeting between activists from London (consume.net) and Berlin[71].

Annual meeting: In addition, there is an annual "Wireless Community Weekend" that takes place continuously since 2006[72] [73].

Local groups: It is a strategic decision of Freifunk to allow the expansion of the model in different regions in a distributed way, and for this all website content including logos are published under a Creative Commons license in order to promote the replication and distribution of the idea. Today Freifunk has expanded to include networks all over Germany, Switzerland and Austria, but in essence, anyone can start a new Freifunk community in any city[74]. Many of these networks are run by small local not-for-profit organizations who are also providing legal structure, money and VPN access towards Freifunk. Since those many small organisations are not federated in any way it is hard to do a precise monitoring of their state.

Advisory council: The above structure was sufficient to hold the community together and place Freifunk.net as one of the most influential community networks in the world. However, with the recent exponential growth and the increased usability of the required hardware and software, there are newcomers that do not always respect the core principles of the network.

As documented: *"For the few community-overlapping decisions we establish a "Freifunk Advisory Council", a representation of community members of the different (German) federal states. This council can be called in when there are conflicts between communities."*

So, Freifunk is a living organism that adapts to changes, trying always to keep as close as possible to the core principles.

3.8.4. Services provided

Freifunk offers all standard local services offered by community networks like chat, email servers and lists, a very active wiki, radio and podcast services over and beyond the freifunk network, blogging,

[68] Association: https://foerderverein.freie-netzwerke.de/organisation/
[69] https://foerderverein.freie-netzwerke.de/projekte/
[70] c-base: https://en.wikipedia.org/wiki/C-base
[71] http://informal.org.uk/people/julian/publications/the_wireless_event/#berlon
[72] http://wiki.freifunk.net/Wireless_Community_Weekend_2006
[73] See here for the latest one in 2016: http://wiki.freifunk.net/Wireless_Community_Weekend_2016
[74] https://freifunk.net/en/how-to-join/find-your-nearest-community/

collaborative editing and more.[75]

Of course, the most important service offered by the network to members and non-members is the free and anonymous Internet connectivity. Unlike networks like Ninux and AWMN, which do not include Internet access in their basic offering, and guifi.net, which clearly separates the community run infrastructure from the services offered on top including Internet access, for Freifunk the provision of free Internet for all is part of its core identity.

It is interesting that while the image of a community network hosting its own services is still alive, the quest for the "killer app" has not been successful for the last 10 years or so[76]. Or as Jürgen Neumann commented during the off-the-cloud workshop at Transmediale 2016[77], *"Local services in community networks are a myth"*.

Note that due to a current German law called "disturber liability", the operator of a wireless LAN configured without any access control (no password) is legally responsible for the actions taken by the users of the network. Such law discourages people to share their Internet connection. Freifunk thus provides Virtual Private Network (VPN) exits on a legally secure ground (often in neighbouring countries). This way, the operator of a node remains anonymous and can not be prosecuted for the actions performed by users. VPN is an important service provided by Freifunk[78] although it can be seen as a centralized layer on top of the distributed Freifunk organization. Currently there are 3 VPN servers in total: Leipzig, Chicago and Dusseldorf but efforts are undergoing to provide more[79].

3.8.5. Implementation of the infrastructure and impact

The growth of Freifunk, especially the last years, is remarkable especially given the non-commercial character of the network and the legal obstacles regarding third-party liability. Today there are more than 40,000 Freifunk nodes all over Germany and neighbouring countries and given the coverage achieved in Berlin more than 350,000 people are expected to have access to the network. This is very important for underprivileged communities like the increased number of refugees that have settled in different German cities the last years.

Freifunk is also very active in protecting the rights of citizens for free access to the Internet through numerous legal struggles in Germany, but also for defending free software like in the recent struggles against the EU radio directive in collaboration with the Free Software Foundation Europe[80].

These legal battles are complemented with numerous educational programs addressing the general public[81] and supporting material such as the recent booklet titled "WLAN for all - Free networks in practice" supported by mabb (Medienanstalt Berlin-Brandenburg)[82]

Finally, the impact of Freifunk has not remained unnoticed and there are numerous articles in the press[83].

[75] Services: https://freifunk.net/services/
[76] Killer app: http://www.zeit.de/digital/internet/2014-06/freifunk-internet-nsa
[77] Transmediale 2016: https://2016.transmediale.de/content/off-the-cloud-zone
[78] VPN: https://freifunk.net/blog/2014/02/das-intercity-vpn/, http://wiki.freifunk.net/IC-VPN, http://blog.freifunk.net/2015/vpn-als-dienst-im-weimarnetz
[79] https://pinneberg.freifunk.net/en/faq.html
[80] https://fsfe.org/activities/radiodirective/
[81] http://jugendnetz-berlin.de/de/freifunk/die-foerderinitiative.php
[82] http://mabb.de/uber-die-mabb/presse/pressemitteilungen-details/wlan-fuer-alle-freie-funknetze-in-der-praxis.html
[83] http://wiki.freifunk.net/Medienspiegel & https://freifunk-hilft.de/medienspiegel/

3.9. Independent Networks Co-operative Association (INCA)

3.9.1. History and Principles

According to their own documentation [62] "The Independent Networks Co-operative Association" (INCA) was set up in 2010 to create an umbrella for the wide range of private, public and community organisations developing or promoting next-generation broadband networks. INCA is a cooperative association set up by a founding group of organisations. A cooperative association in this context means a type of trade association that as well as promoting members' interests also allows them to pool resources and work together as a cooperative. It is inspired by the example of the NTCA in the USA (The Rural Broadband Association).

INCA's vision according to them is: *"to achieve 100% coverage of next generation broadband as quickly as possible, nobody left behind. To get there, particularly in harder to reach areas, INCA advocates a partnership approach bringing together public, private and community sectors to plan next generation network coverage regionally and locally. It is our belief that by working together, sharing knowledge and experience, we will facilitate investment, encourage innovation and speed up deployment for a truly next generation broadband Britain.*
As a co-operative organisation, INCA aims to help members share knowledge and develop activities of mutual benefit. INCA promotes common technical and operational standards amongst local projects, supports the Next Gen Events programme and runs a seminar programme for its members. INCA also actively promotes the sector and lobbies government and Ofcom to ensure that the voice of independent networks is heard".

3.9.2. Stakeholders

Being a second-second layer organization, the stakeholders are not individuals, but organizations involved in the common vision of full broadband coverage in the UK. That includes networks with different operational and business models but all independent from the incumbent, governmental organizations and professionals. There is a wide range of members such as network owners; network operators; network managers; access networks; middle mile networks; network hubs and exchanges; organisations, including public sector, that are developing or promoting independent networks; equipment suppliers.

Full members are networks: organisations that are building or operating eligible networks and have a responsibility for the future of those networks. Aspirant networks: organisations planning to build networks that will become eligible networks.

An eligible network would be independent of the incumbent network operators (an "altnet") and either: Open, offering wholesale access to service providers that offers end users a complete bundle of services; Less open but owned by the community it serves. Eligible networks include open (or mutually-owned) backhaul as well as "first mile" networks. Example eligible networks: A local FTTP network built with private or public sector investment offering wholesale access to service providers. A local FTTH network owned by the local community and offering its own ISP, TV and telephone services. A backhaul network co-owned by networks that use it.

Supporting members are organisations that support and contribute to the aims of INCA but which are not networks themselves. Example supporting members can include: Equipment suppliers, Network constructors, Managed network operators, Public sector bodies encouraging the development of networks, other organizations that support the aims of INCA.

Representative and inspiring examples of CN members are rural fibre optic broadband networks such as Cybermmor[84] in the North Pennines and B4RN – Broadband for the Rural North[85]. B4RN is based in rural Lancashire and extending into North Yorkshire and Cumbria. Set up by a volunteer group in late 2011, B4RN has connected more than 2100 premises to its pure fibre network, offering speeds of 1Gbps at very cost-effective prices. The project was founded as a community benefit society (a form of co-operative) and has raised £4m in community shares and loans to finance its operations. The stakeholders in B4RN are the investors (an investment is made of shares, and all shareholders are members of B4RN), the landowners, the professionals (contractors) and volunteers. An army of volunteers, now numbering in the hundreds, helps the core B4RN team keep costs down and guarantees a high level of local community involvement. It also means B4RN can reach all properties in their catchment area. They are literally digging their own gigabit fibre network, with nobody left behind. Not surprisingly take-up is excellent, averaging 65% in the communities B4RN serves. This is astonishingly high by industry standards. As word spread B4RN has experienced a snowball effect with more and more neighbouring parishes wanting to get involved. In fact B4RN and guifi.net started independently to deploy rural fibre nearly at the same time and following similar methods without any coordination.

However, not all INCA members are community-owned, bottom-up or non-profit. There are also several commercial operators alternative to the large incumbent (British Telecom, BT), but using commercial investment to build brand new networks and establish close relationships with the communities they serve. An example of that is Hyperoptic, the first provider to make 1Gbps speeds available to broadband subscribers in the UK. Set up in 2011 Hyperoptic focuses on providing urban residential apartment blocks with ultrafast fibre connections (Fibre to the building – FTTB). Now present in 20 cities, Hyperoptic has connected buildings with around 200,000 premises making it one of the largest of the Altnets. Backed by and investment fund managed by Soros Fund Management LLC, Hyperoptic has recently attracted £21m of European Investment Bank funding, taking total investment to £75m. One interesting fact is that around 50% of Hyperoptic's footprint is in 'white' areas of the Broadband Delivery UK government plan – i.e. places that don't yet have BT's superfast broadband – despite the fact the are an urban provider.

In fact, the example of INCA highlights the importance of second-layer organizations (or co-operative organisation like this) to aggregate smaller and local initiatives and enjoy the benefits of scale in sharing knowledge, develop activities of mutual benefit, and become visible and have a dialogue with governments, regulators or other agents as a sector or collective.

3.9.3. Implementation of the governance

Communication and coordination tools

Communication is based on a email mailing list, a periodic email newsletter, "road shows": workshops done at diverse locations to discuss in the local context, diverse local or related events, and an annual conference (e.g. INCA Conference October 19, 2016 in London).

[84] http://www.cybermoor.org/table/cybermoor/cybermoor-networks/
[85] http://www.b4rn.org.uk

Participation framework

Full members have a vote. They pay a two-part subscription fee: An annual subscription, and a participation fee in proportion to network size. Supporting members do not have a vote but otherwise play a full part in the deliberations of the association. They pay a membership fee.

Governance tools

The model rules adopted by INCA tries to have flexibility on the exact arrangements for governance of the society. The following procedural rules or standing orders shall apply until amended by simple majority in a general meeting. There is a chair, and an elected 5-12 (currently 6) board of management, a 'scrutiny and liaison group' to formally represent community and voluntary projects, and an assembly.

The Board of management is elected by and accountable to the members of INCA in a general meeting at which each Member of INCA has one vote. An elected board member is a deputy of a member organisation. Board members are individuals, not representatives or delegates of members. The Board will appoint a chair from among its members. The Board may co-opt additional members, up to a maximum of 5 and not to exceed the number of elected members. The quorum of the Board will be one half the elected members rounded up to the nearest whole number. The Board will appoint officers including but not limited to a chair, chief executive, finance officer and secretary. Board members will be reimbursed for reasonable travel expenses for attendance at board meetings. Membership of the board will not be remunerated. Members of the cooperative association shall abide by a code of practice.

3.9.4. Services provided

Being a federation of so called Altnets, INCA develops common policy analysis and campaigns, common position documents, documentation of best practices, public events, sponsorship opportunities, INCA Special Interest Groups, Networking opportunities, access to Policy/Regulatory advisory service.

3.9.5. Implementation of the infrastructure and impact

Sustainability

The sustainability of INCA is supported by the annual membership fees. Gold members with an active involvement contribute £4000 (6 in 2016), Silver members support with £1000 (24 in 2016), public sector members contribute £500 (4 in 2016), and associate members (15 in 2016) are small and new organisations that wish to get involved in INCA, participate in events, networking and information sharing, contributing £150.

Results

INCA's Member Survey 2016 reveals that the Altnets already play an important role in the market and shows that they are on track to deliver a significant proportion of the FTTP[86] the UK requires 3.11.

[86]Fibre to the Premises: can refer to Fibre to the Home or to the Building. See https://en.wikipedia.org/wiki/Fiber_to_the_x

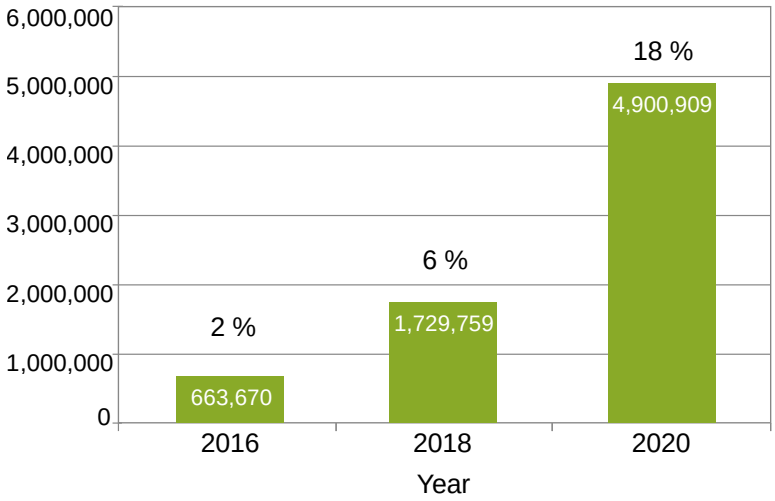

Figure 3.11: Altnet FTTP status and deployment projections in the UK. Number of premises (locations) passed and percentage of total UK premises for different years). Source: INCA Member Survey 2016 and [3].

In 2016 Altnets already pass more than twice as many premises with FTTP as BT: 663,670 versus 300,000 [3].

Lessons learned

The main lessons can be summarized from the executive summary of the recent "Building Gigabit Britain Report" [3] which describes the how the vision has reached to the current status, what is their mission and how Altnets can contribute to achieve their ultimate aim of a "Gigabit Society":

"Digital connectivity is already a critical building block for a strong modern economy and is set to become even more important. The world is on the verge of the next phase of the digital revolution, which will transform all aspects of our lives through tech-enabled developments such as the Internet of Things, smart cities and automated vehicles. Only countries with digital infrastructure fit to support a "Gigabit Society" will be able to fully exploit this new digital wave.

The UK is at an important juncture in determining how to develop the digital infrastructure needed to build on its existing digital strengths. The regulator Ofcom declared in its Strategic Review that "fibre is the future" and is putting plans in place to deliver this vision. The previous Digital Economy Minister, Rt Hon. Ed Vaizey MP, spoke of the need for "Gigabit Britain" to succeed today's Superfast Britain and a Digital Strategy outlining further details is expected shortly.

A mix of digital networks will be needed to support Gigabit Britain, with wireless networks in particular playing a critical role. However, INCA argues that to meet the Government's goal of ensuring "the UK builds the right infrastructure to maintain [its] position as a world leading digital nation", a significant step-up in the extent of Fibre to the Premise (FTTP) networks is required. The alternative networks – or "Altnets" – are already building these future-ready networks and can play a central role in delivering the scale of FTTP required in the UK, if the right policy and regulation is in place.

Gigabit Britain will need networks that deliver not just fast download speeds to some of the people some of the time (as is the case with copper-based networks such as Fibre to the Cabinet (FTTC) and G.fast, the next copper upgrade), but networks that consistently, reliably and securely deliver high upload speeds, low latency and ultrafast download speeds. FTTP is the only fixed-line network able

to fully deliver against these criteria and support a Gigabit Society. Fibre is also essential for the roll out of 5G and other wireless networks, has far lower operating costs and energy consumption than copper, and can help the UK meet wider policy objectives, such as increased productivity, a balanced economy and a smart approach to energy and public services.

Most of the UK's international competitors have already understood that strong future economies will be built on FTTP and are making firm progress towards widespread coverage, often spurred on by clear government visions for a Gigabit future and a supportive regulatory environment. However, while the UK performs well against its peers on today's key connectivity metrics – superfast speed, coverage, take-up and price – it performs poorly against the critical metric for tomorrow's connectivity – the extent of FTTP deployment. Unless there is a swift and significant increase in FTTP deployment, the UK will trail behind all other developed nations on connectivity, significantly undermining its long-term economic growth and competitiveness.

BT has made clear that its plans for the future rest not on fibre, but copper. The upgrade of the Openreach network to G.fast promises eye-catching potential top download speeds but the copper in the connection will simply repeat today's broken broadband problems: unreliable service, a patchwork of "up to" speeds and post-code variations and potentially an even greater digital divide between those with 1Gbps+ speeds and those without. The UK must therefore look to BT's competitors to lead the FTTP charge. Virgin Media will play a significant role in providing competition, but a third competitive force is required to deliver FTTP deployment at scale, sufficient competitive pressure on BT, and choice for consumers.

Collectively, the Altnets provide the additional competition required. They are deploying FTTP, growing fast and attracting significant and rising investment. INCA's 2016 Member survey shows that Altnets already pass more than twice as many premises with FTTP as BT. By 2020 the Altnets forecast their FTTP networks will pass nearly 5m premises (or 18% of the UK) – 1.5m premises more than BT and Virgin Media's planned FTTP builds combined. The Altnets' say that their deployment plans could increase by between 25% and 50% in a more supportive policy and regulatory environment. To build Gigabit Britain, Government and other stakeholders must therefore recognise the significance of the Altnets and ensure that policy and regulation maximise their potential.

To do this the Government needs to build on Ofcom's Strategic Review announcements and go further, by setting out an ambitious and coherent "Gigabit Britain Strategy" focused on encouraging commercial investment in FTTP networks. To give focus to the Strategy and confidence to investors, network builders and operators, the Government should announce a target for the majority of UK citizens to have access to a FTTP connection by 2026 and near universal coverage by 2030. INCA suggests that coverage of 80% of the UK with commercial FTTP by 2026 is an attainable goal, which is also in line with the level of competitive infrastructure that Ofcom believes can be achieved. Based on their current deployment trajectory, and on the condition that the recommendations in this paper are adopted, the Altnets are confident they are on track to reach around half of the 80% commercial coverage target by 2026."

The target is ambitious but achievable through commercial deployment rather than public subsidy: the cost of delivering FTTP has fallen significantly in the last decade and the Altnets' deployment forecasts, combined with the sharp increase in commercial investment in FTTP elsewhere in the world, prove there is commercial appetite to deploy at scale – in the right policy and regulatory conditions.

The coming digital revolution provides an opportunity for the UK to translate its existing digital strengths into significant social and economic gains. However, to do so requires a quantum leap in the quality of our digital infrastructure. The Altnets are already building FTTP networks fit for Gigabit Britain and are on course to reach a significant proportion of the UK by 2020. However, a

clear Government strategy that prioritises competition and investment in truly future-ready networks is required to unlock the Altnets' full potential.

4. Comparative Analysis and Discussion

This chapter looks at a subset of CNs under study and provides elements for a comparative analysis of their external view, their online web links, and a summary of their internal view, their main organizational features from a decentralisation perspective. The chapter concludes with a discussion of the main differences, opportunities and challenges.

4.1. Mapping European Community Networks and their online presence

As part of the exercise of mapping European CNs, we have started looking at the online presence of these groups. By using the web-crawler Hyphe developed at Sciences Po's Medialab, we put together a network of web entities belonging to community networks across Europe[1].

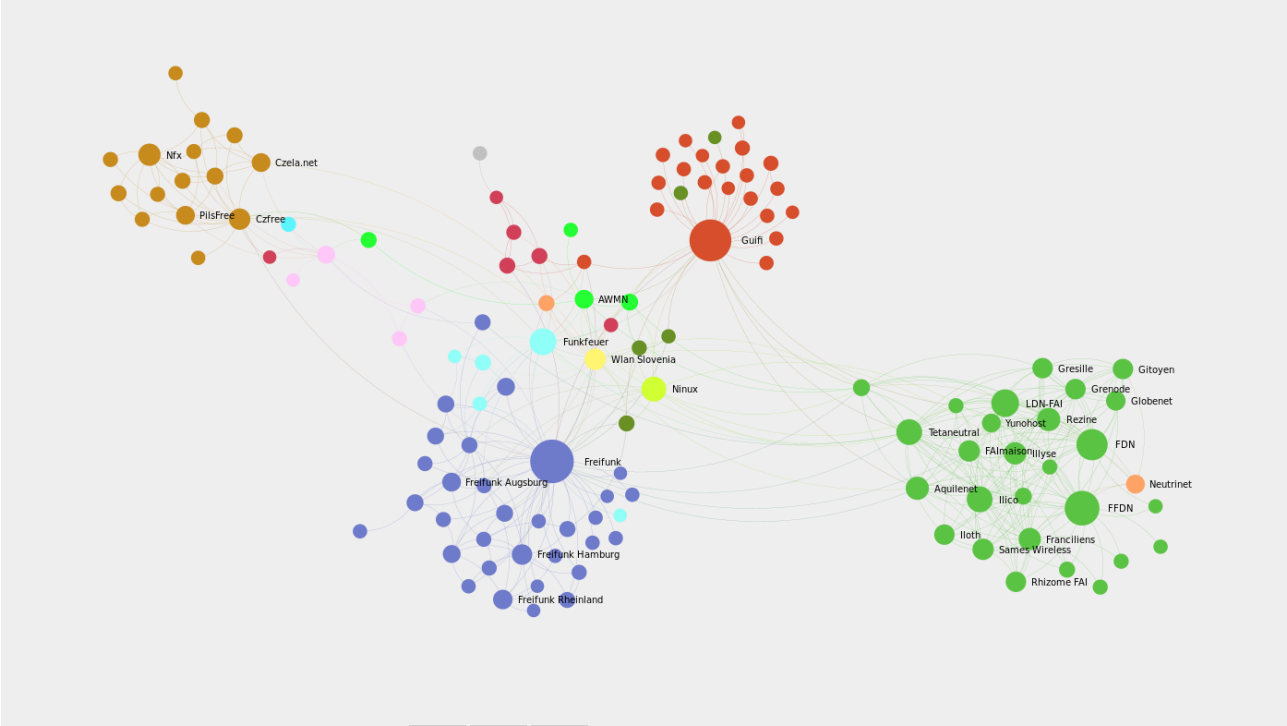

Figure 4.1: Cartography of the online presence of European Community Networks.

4.1.1. Methodology

Hyphe is a tool allowing researchers to easily explore the social space of the Web. You start by "feeding" Hyphe with a first batch of websites URLs . Hyphe then "crawls" this batch of Web pages.

[1] See the map online at http://map.netcommons.eu

Every time, they encounter a link to a new website (or what Hyphe's developer have called a "Web entity", which can also be a subdomain or an extension of the initial website), the later is indexed. After this first round of exploration, the researcher goes to the index and curate these "discovered" Web entities to decide if she wants to add them to her corpus.[2]

For us, it was quite simple: Our goal was to study online relationships between CNs by and and discover CNs we did not know about and make an exhaustive inventory of the field. We entered a list of a about 70 CNs we already knew about, crawled them, and then checked whether the discovered websites they linked to matched with a community networks somewhere in Europe. When such was the case, we would add them to our corpus and repeat the crawling process on these new entities. When that iterative process was done, we did a last crawl of the whole corpus to be sure that we had caught all the existing links between the more than 130 nodes of our network.

4.1.2. Analysis

The map is the result of this process. The first noticeable feature is the prominence of four national communities:

- Freifunk in Germany, with its various local groups in German cities.
- Guifi in most of Spain's regions, as well as a couple of Portuguese cities.
- The Federation FDN in France (plus one in Belgium).
- The apparently less structured Czech community.
- In the middle of the graph stands Ninux communities in Italy, Funkfeuer in Austria as well as other CNs in Greece, Hungary, Slovenia and other countries.

This online map gives an idea of where the growing movement of community networks is the most dynamic, but of course the shape of the graph cannot be taken at face value. Indeed, the structure of the Web and CNs' online presence cannot account for all the various forms of relationships and collaborations between them, much less give an idea of their real life features (e.g. in governance or technical infrastructures).

Ninux, for instance, is a very horizontal community made of local groups in major Italian cities. But at the contrary of Freifunk groups, its local Ninux groups do not have their own websites. Hence, our map show only one node for Ninux when we should have at least half a dozen of them. Also, some CNs appear unconnected to the rest of the network, not necessarily because they these CNs are completely isolated from other communities but because they may use flash, javascript, or other technologies that Hyphe's crawlers have a hard time deciphering.

Because of these important limits, we should be careful not to draw hasty conclusions regarding variations among national communities. For instance, the map tends to represent Guifi as a very vertical community in which all the regional groups point to the main Guifi website, without any link between themselves. But this is the direct result of the design choice for the online presence of these groups, whose web entities are in fact subdomains of the main Guifi site with a very basic webpage. FFDN, on the contrary, appears much more decentralized, with many links across its nodes. In part, this reflects real differences in governance and legal structures between the Guifi community and Fédération FDN: The Guifi Foundation acts as the central proxy for resource management and governance for all of its local groups, while FFDN has more of a coordination role, with local groups retaining much autonomy in these areas. That being said, the direct forms of offline and online collaborations suggested by the links between FFDN's members are also found within Guifi, despite

[2]For more on the Hyphe methodology, see [63].

the fact that the later do not have direct links between them. Based on the map, one may think that Freifunk lies somewhere in the middle between Guifi and FFDN, while it is is actually much more decentralized and horizontal that the later.

Finally, the size of the nodes depends on the number of incoming links. This design choice that makes sense for analyzing a network of Web entities, but it cannot account for important size variations. Freifunk and FFDN appears to have approximately the same number of local groups and a similar node sizes. In reality, FFDN has about 2,500 members using its members Internet access service while Freifunk boasts more than 35,000 wireless access points (each being used by by multiple users). Here these significant differences in size are clearly flattened out.

Despite these important limits, such a Web mapping exercise has allowed us to a get a first general picture of our field of study. It can help us come together with research questions and hypothesis that will be assessed during upcoming fieldwork. It is a useful first step we can build upon as we move forward: In the future, we will be able to ask people taking part in these various networks to help us describe all of these group according to our set or categories and offer a public vizualization of the map and its accompanying data.

4.2. A (de)centralisation-based typology of CNs

This section aims at contributing to the definition of both the perimeter of CNs and of internet commons by situating them within the broader ecosystem of platforms, participation, and collaboration economy. As CNs can follow a diversity of models, the level of their (de)centralisation has been chosen as a parameter to describe several of their features. Following Dulong de Rosnay & Musiani [64], we can characterise CNs based on the degree of (de)centralisation of these selected design features. The objective is not primarily normative, but descriptive and analytical. There is no "ideal" set of settings to make the perfect CNs, but we can have a systematic critical perspective on the different layers of peer production design. The following five design features proposed in the typology of Dulong de Rosnay & Musiani are based on distinctions observed in the literature on peer production, crowdsourcing and the commons, and are intended to apply to peer production platforms and networks:

1. Governance model: Governance of work patterns, social organisation, the set of processes including terms of use, production rules, work process, investment and design choices. It can be concentrated among the hands of an oligarchy, or completely decentralised with a broad participation from all members.
2. Legal representation: Legal representation, with the existence of a structure or not, but also ownership of the means of production, as the access to infrastructure and spectrum can be more or less concentrated.
3. Technical infrastructure: Technical architecture and design, certain nodes can have more importance, or in the theoretical extreme case of fully distributed mesh networks, no node is essential.
4. Value generation: Value sharing, model to reuse benefits to deploy more infrastructure, contribution to expanding the network as a commons. It can be ranging from exclusive appropriation of the economic benefits by the platform owner(s) in the case of commercial ISPs to redistribution of social benefits, to the CN, to other networks and to the society at large.
5. Legal situation applying to the output: Rights related to the peer-produced resource, in the case of CNs, the terms of use, licensing and legal liability model, which can concentrate the

risks, possibly assigning tort to visible users, or distributing tort among users as no warranty is provided.

Appreciating the level of (de)centralization with regards to these features is meant to untangle the various features and components of CNs, as well as to contribute to internet science, as peer production and the commons are an increasingly complex field. CNs can indeed be considered as global commons, influenced by rules pertaining to:

- Infrastructure commons because of their physical materiality,
- Natural commons because of their dependence on access to spectrum,
- Knowledge commons because of the competences needed to deploy and maintain a CNs,
- Urban commons because of their local roots, organisation, and value sharing
- Digital commons because of the objective of communication and transmission of information subjected to the same regulation and challenges.

Finally, by identifying parameters which can be adjusted, this approach sets the ground to future deliverables of WP1 and WP4 as the project will provide recommendations to improve the sustainability of CNs as commons. Organizational and procedural forms used within peer-production possess a variety of features that impact (and are impacted by) results obtained & types of norm constructed on the platform. This mapping reveals the settings we have at our disposal to optimise and regulate CNs understood as techno-socio-legal complex systems.

The following Table 4.1 is illustrating how these features observed in the 5 CNs can be more or less decentralised:

Community	Scale	Commons-based governance	Legal representation	Infrastructure	Economic model	Licensing model
Guifi	21 provinces in Spain, and for instance 41 counties in Catalonia, other countries: Africa 4, America 16, Asia 2, Europe 14	Mixed (decentralized at local level but strong commons-based gov. at level of Guifi.net foundation). Related groups around software, Internet connectivity, contents as commons	Yes (local and national: telecom regulation, agreements with external orgs, tax, clearance of compensations, research, development)	Decentralized optical fibre and WiFi networks, acts as regional IX (private transit providers, mechanism to share and access transit capacity)	Subscriptions, crowd-funding, economic compensation system (importance of professionals)	Community License (FONN), agreements with external orgs, and compensation agreements
FFDN	28 local organizations/1500 subscribers	Decentralized (importance of core volunteers)	Yes (both local and national) + litigation	Decentralized (WiFi) / Centralized (leased ADSL)	Membership fees, subscriptions, donations	Bylaws, internal rules (réglement intérieur), charter of good practices and common commitments
Freifunk	304 local groups	Very decentralized	No (but litigation strategy nevertheless)	Very decentralized (free contribution of WiFi access points)	Volunteer contribution by citizens and professionals	Informal agreement
Ninux	350 nodes	Decentralized (importance of core volunteers)	No recognised legal entity	Decentralized in theory (WiFi), but bottleneck at supernode level	Volunteer contributions	Pico-peering agreement
Sarantaporo	153 nodes	Organization-centered (local support groups, open meetings, participatory design).	Yes (Non-Profit Organization)	Decentralized (WiFi) / Centralized bandwidth provider.	Volunteer contributions, individual donations, collective donations, subscriptions, collaboration with companies.	Informal agreement.

Table 4.1: Comparative table of main European CNs

4.3. Discussion

Community Networks have a) macroscopic and external aspects, as an infrastructural resource system critical for a given community, that can be measured in terms of coverage and socio-economic impact; b) macroscopic and internal aspects that reflect coordination and adaptation according to its institutional structure, constitutional principles; c) microscopic aspects that reflect individual changes and interactions that reflect the specifics of the self-organized and de-centralised structure of these institutions, that differ across places.

We have explored the mappings between these institutions created by communities of practitioners and the world of theories about commons, both from a theory perspective, from the practice and social action and vice-versa. Network infrastructure commons, by its mission of digital inclusion and the rivalry of packet switched networks, not rival in theory or small scale but quite rival when implemented and deployed at scale in communities, are always at the brink of congestion. We are fortunate that the Internet technology is sensitive and reactive to short term congestion (queueing of IP packets in devices, congestion-avoidance in TCP). Furthermore, CNs have developed institutional tools to handle sustainability and resilience of these infrastructures. This is achieved by balancing contribution and consumption and promoting and supporting maintenance and expansion. The result is more participants with more connectivity resources and wider reach.

There is a distinction between the data links (wired or wireless), the network infrastructure (the resource system formed by routers and links), the content available and the services that operate over that infrastructure, and the interconnection to the global Internet. Each of these ingredients can be bundled or treated separately. For instance data links can be either built from commodity devices or obtained from third parties such as dark fibre operators or open access network operators. The rest can come from hosts inside the CN or from outside through interconnection infrastructures like Internet eXchanges.

Participation in the infrastructure results from the dilemma of open access versus a commons model. This results in technical choices and a balance between an open access network with access points that allow connecting terminal devices (a computer) that act as *consumers* of connectivity, and a *prosumer* model with intermediary devices (a router) that expand the coverage and capacity of the network. The technical choices in the computer network relate to organisational choices in the access and sustainability of the commons infrastructure.

Differences in access methods and level of involvement lead to different types of stakeholders: Authorized users with terminals (and access point users), full participants with their own routers, and professional participants that may deploy, manage, and maintain from a few to many nodes in the infrastructure. The operational procedures, the governance mechanisms and collective-choice actions can and should take these roles into account. There are other relevant stakeholders such as governmental orgs, commercial participants, the role of IXPs, content and service providers. The coexistence and complementarity of all these is critical for the subsistence and expansion of these infrastructures. The neutrality/genericity of a network infrastructure allows not only community participants but also external participants outside the scope of the CN to benefit from it.

As technology savvy social groups, the promoters and participants have developed or adopted a wide range of tools to support coordination, management, governance, transparency and monitoring of the resource system. This computer-supported coordination and sharing tools has enabled CNs reaching much higher scale and formalisation of procedures. Along similar principles, each CN under analysis has develop comparable but sometimes surprisingly different ways to achieve similar goals.

The cooperative model of these infrastructures oriented to cost sharing, without extracting value

(profit) from the infrastructure itself (although possible with the usage and alienation of connectivity), contributes to create socio-economic benefits, as in many other critical infrastructures for society. Measuring the impact is the key test to the relevance and impact of this infrastructure. That is difficult to assess as it escapes the pure economic impact and has multiple effects on most activities that can benefit from the availability of an inclusive and welcoming communication infrastructure.

These constructed commons infrastructures result in formal and informal rights implemented as standardized documents such as license, agreements, settlements, etc. as a result of constitutional choices, that range from non-existent, informal, formal in different CN, and that are defined or prescribed in an early constitutional phase or later on in the lifetime of CNs with more or less conflict in their adoption.

Legal recognition is an important factor given the infrastructural nature of the commons. The legal implications of the resource system (a telecommunications or networking infrastructure), the kind of extracted resource (connectivity and the regulation of service provision), the competition and coexistence with external actors (other ISPs and telecom providers) and the interaction with the public administration that regulates many aspects such as regulation of access to public space (radio spectrum, node and link deployment, sharing with other utilities).

A key challenge is the effect of scale (in number of participants, in network speed, in geographic coverage) that can have in the diversity of ways to organise according to local particularities, and the need for standardisation and avoiding the ”single-point-of-failure” of a few leaders and teams that are putting a lot of personal time leading these initiatives. In this case sustainability and scalability could come with decentralization, locality, but also professionalization, but that may have also transformational effects on the structure of these initiatives.

The complexity and challenges around this environment suggests the development of second layer organisations and federated structures that can bring efficiencies, economies of scale, coordination and stability to these initiatives (e.g. in terms of legal methods, software development, knowledge sharing, legal protection, research, influence in policies and regulation). Several international initiatives and forums have allowed and supported communication and coordination among CNs, where this research project is contributing.

Research is being recognized as key for the refinement and resilience of CN, leading to understanding, optimization, but also to the development of solutions to blocking factors in these infrastructures in the short or medium term.

5. Conclusions

Community networking infrastructures have been developed in many locations and communities to address the essential need of citizens to participate in the digital society, to support communication in the artificial digital space as we can do in the natural acoustic space. CNs, as global commons with a central artificial material commons component, are critical enabling infrastructures for the digital world. These infrastructures enable self-provisioned and self-organized ways to build and ensure social interconnection and access to knowledge, content, communication. As the report shows, under common principles, diversity makes a difference, and each CNs has created diverse local institutions or organisational structures adapted to local conditions and needs, with different levels of sophistication. Each initiative is adapted to its locality, with slightly different starting points, values, strengths and weaknesses, and diverse levels of development and structuring.

The theory of the commons allows us to look at the organisational design and experiences of several CNs from multiple perspectives. We have looked at resilience and sustainability in a common property regime, its incentives and sustainability mechanisms.

Community Networks have a local impact, ranging from a club (with exclusion) of the initiated in the networking arcane, up to those committed to connect the unconnected and expanding the network infrastructure for all. Scale matters a lot, particularly in an interconnected world that is dominated by large companies in the telecom market. These initiatives create a larger social base to have an influence in governments and law makers. Research activities like this one adds to resilience, sustainability and adaptability.

Given the importance of size and proximity in communities, CNs tend to form decentralized structures beyond the local realm: federated structures or second-layer organizations. In different ways, this is the case of Ninux, Freifunk, guifi.net or INCA. Second-layer organizations allow to aggregate smaller and local initiatives and enjoy the benefits of scale in sharing knowledge, sometimes also governance, services, infrastructure. These aggregate organizations become a visible actor for the dialogue with governments, regulators or other agents as a sector or collective. In addition, CNs are inter-connected, with communication and coordination across initiatives in different regions.

This work extends a previous version (D1.1) [5] including in the analysis additional community networks, including the most representative WiFi enabled networks such as Freifunk (DE), AWMN (GR), mixed wired (optical) and wireless such as guifi.net (ES) or Cybermoor (INCA, UK), and mostly optical fibre networks such as Broadband for the Rural North (B4RN) (INCA, UK).

A. Community Networks around the world

Many initiatives are sometimes defined as Community Networks, but only when looking at their organisation, governance and business model we can classify them as crowdsourced networks (a loose and informal interconnection of routers without a socio-economic organisation), as community networks (as defined in Section 2), as top-down ISPs (such as Wireless ISP or WISP, for profit or not), as municipal networks (run or managed by a municipality or other governmental organisation), among several other models.

Table A.1 contains a list of Community Networks around the world, as reported in diverse sources. For most of them we have contact information (web site, email contact). Their status is very diverse[1]. Some were active in the past and now they seem inactive, even with their web site down. Some of them have been confirmed as active and a few have replied with interest in further study. Typically the contact persons are volunteers leading the networks and many times they may not have the time to participate in interviews or discussions with external people sending them emails and stating willing to "study them". It is also difficult to distinguish between a non-responsive contact and a non-operational network. The business, participation and organisational models can vary a lot under the term CN. The only way to find out would require a detailed analysis that may require a visit to the community, interactions with a significant amount of local stakeholders, and finding out complementary information through the social network of contacts between different CNs.

As a result of a survey, we collected details about a small subset CNs that accepted participating in a discussion about organisational models and an analysis of their resilience and sustainability. A summary of the basic facts is presented in Table A.2 and Table A.3.

[1]Symbols for "Active" column: operational: YES, not operational: NO, web site active: +, no information: N/A.

Cont.	Country	Place	Name	Active
Africa	Ghana		Wireless Ghana	N/A
	South Africa		Wireless User Group South Africa (SWUG)	YES
		Johannesburg	Johannesburg Area Wireless User Group	+
		Cape Town	Cape Town Wireless User Group	+
		Durban	Durban Wireless Community	+
			Potchefstroom Community Network	+
		Pretoria	Pretoria Wireless Project (Centurion)	N/A
			Pretoria Wireless User Group	+
			Stellenbosch Community Network	+
			Wireless Africa	YES
	Zambia	Macha	LinkNet	
Asia	India	Dharamsala, H.P.	AirJaldi Community Wireless Mesh Network	YES
	Indonesia	Batam Island, Kepulauan Riau	Batam Wireless Internet Community (BWIC)	+
	Nepal		Nepal Wireless Networking Project	YES
		Kaski	Community Wireless Mesh Network	+
	Afganistan		Fabfi	N/A
	Israel		Arig Israel's Community Mesh Network.	+
Australia & Oceania	Australia	ACT	Canberra Wireless Network	+
		New South Wales	Bathurst Wireless	+
			Coffswifi.net	+
			Sydney Wireless	+
		Northern Territory	The Mesh, Darwin	N/A
			Darwin Wireless, Darwin	+
		Queensland	Darling Downs Wireless, Toowoomba	N/A
			Brismesh, Brisbane	N/A
			Townsville Community Wireless	N/A
			Cairns Wireless	N/A

Cont.	Country	Place	Name	Active
			SuncoastMesh, Sunshine Coast	+
		South Australia	Air-Stream Wireless Incorporated, Adelaide & surrounding	N/A
		Victoria	Ballarat Wireless	N/A
			Bendigo Wireless	N/A
			Melbourne Wireless	N/A
			Lara Wireless	N/A
		Western Australia	WAFreeNet, Perth	N/A
		Tasmania	TasWireless, Tasmania	N/A
	New Zealand		Yobbo Wireless Community	N/A
			Computer Clubhouse 274 Community Wireless	N/A
	Austria	Vienna, Graz, Bad Ischl	Funkfeuer Vienna (Funkfeuer Wien)	+
		Hofkichen	LZB-Net	N/A
		Wels	Funkfeuer Wels	+
		Linz	Funkfeuer Linz	+
		Traunviertel	Funkfeuer Traunviertel	N/A
		Salzkammergut	Funkfeuer Salzkammergut	+
		Graz	Funkfeuer Graz	YES
		Voitsberg, Deutschlandsberg	Funkfeuer Weststeiermark	+
	Belgium	Mechelen	DraadloosMechelen	+
		Brussels	ReseauCitoyen	+
		Antwerp	WirelessAntwerpen	+
			WirelessBelgie	+
			WirelessGent	+
		Brussels	WirelessBrussel	+
		Leuven	WirelessLeuven	+
		Brugge	WirelessBrugge	+
		Blankenberge	WirelessBlankenberge	+
	Bosnia and Herzegovina		United wireless communities in Bosnia	+

Cont.	Country	Place	Name	Active
			United wireless communities in Republic of Srpska	+
		Sarajevo	saWireless	N/A
		Visoko	Viwa net	N/A
		Kalesija	NEON Solucije	+
		Banjaluka	BLwireless	+
		Banja Luka	BDB@wireless	+
		Mostar	mo-wireless	+
		LP	LPwireless	+
		Bijeljina	BNWireless	+
		Neum	NeumWIRELESS	+
	Czech Republic		CZFree.Net	+
	Czech Republic	Celkovice	Czela.net	+
	Czech Republic	Hradec Králové	HKFree.org	+
	Czech Republic	Kladno	KLFree.Net	+
	Czech Republic	Liberec	LBCFree.net	+
	Czech Republic	Plzen	PilsFree.net	+
	Czech Republic	Unhošt	UNHFree.net	+
	Czech Republic	Kutná Hora	KHnet.info	+
	Czech Republic	Mnichovo Hradiště	mh2net	+
	Czech Republic	Ostrava	Evkanet	+
	Czech Republic	Prague	CZF-Praha	+
	Czech Republic	Křivonet	Krivonet	+
	Czech Republic	Prague	JM-Net	+
	Czech Republic	Slavičín	SLFree.Net	+
	Czech Republic	Varnsdorf	Gavanet	+
	Czech Republic	ACzW	AirDump.Net	+
	Czech Republic	Holov	NobodyNet	+
	Czech Republic	Prostejov	PVFree.Net	+
	Czech Republic		Svobodna Praha	+

Cont.	Country	Place	Name	Active
	Croatia		Map of Croatian Wireless Networks	+
	Croatia		Croatian Wireless Association	+
	Croatia	Velika Gorica	VGWireless	+
	Croatia	Rijeka	RiWireless	+
	Croatia	Dugave, Zagreb	Dugave Wireless	+
	Croatia	Pula, Zagreb	PUWireless	+
	Croatia	Baska, Krk	BSWireless	+
	Croatia	Bakar	BKWireless	+
	Croatia	Đakovo	DJWireless	+
	Croatia	Karlovac	KAWireless	+
	Croatia	Vrbovec	VRWireless	+
	Croatia	Zabok	ZBWireless	+
	Croatia	Zadar	ZDWIreless	+
	Croatia	Krizevci	WirelessKZ	+
	Croatia	Zagreb	ZGWireless	+
	Croatia	Cakovec	Medimurje Wireless	+
	Croatia	Varaždin	Extreme Wireless	+
	Croatia	Osijek	OSWireless	NO?
	Croatia	Zagreb	ZNET	+
	Croatia	Zagreb	WiFiHR	NO?
	Croatia	Ludbreg	Ludbreg Wireless	NO?
	Denmark		DIIRWB, Djurslands International Institute of Rural Wireless Broadband	N/A
	Denmark	Glesborg	Djurslands.net	+
	Finland		OpenSpark	+
	France		Fédération France Wireless	+
	France		Lille sans fil	N/A
	France		Wifi Montauban	N/A
	France	Toulouse	Toulouse Sans Fil	+

Cont.	Country	Place	Name	Active
			Rural Area Networks Webring	+
			Freifunk.net, general page for Germany	+
		Aachen	Freifunk Aachen	+
		Augsburg	Freifunk Augsburg	+
		Berlin	Freifunk Berlin	+
			FreiFunk Prenzlauer Berg	+
		Bielefeld	Freifunk Bielefeld	+
		Bochum	Freifunk Bochum	+
		Bradenburgo	FreiFunk Gadow	+
		Dresden	Förderverein Bürgernetz Dresden eV	+
		Chemnitz	Freifunk Chemnitz	+
		Dresden	Freifunk Dresden	+
		Gießen	Freifunk Gießen	+
		Gronau (Westf.)	Freifunk Gronau	+
		Halle	Freifunk Halle	+
		Hamburg	Freifunk Hamburg	+
		Jena	Freifunk Jena	+
	Germany	Kiel	Freifunk Kiel	+
		Cologne	Freifunk Köln / FreiFunk Koln-Bonn	+
		Leipzig	Freifunk Leipzig	+
		Lübeck	Freifunk Lübeck	+
		Lüneburg	Freifunk Lüneburg	+
		Mainz	Freifunk Mainz	+
		Niedersachsen	Freifunk Hannover	+
		Oberhausen	Freifunk Oberhausen	+
		Oldenburg	Freifunk Oldenburg	+
		Paderborn	Freifunk Paderborn	+
		Potsdam	Freifunk Potsdam	+
		Remscheid	Freifunk Remscheid	+

Cont.	Country	Place	Name	Active
		Rheinland, around Düsseldorf	Freifunk Rheinland	+
		Rostock	OpenNet Initiative	+
		Weimar	Freifunk Weimar	+
		Wermelskirchen	Freifunk Wermelskirchen	+
		Wuppertal	Freifunk Wuppertal	+
	Greece		Wireless Networks Association	+
		Athens	Athens Wireless Metropolitan Network	+
		Sarantaporo	Sarantaporo.gr WiFi Networks	+
		Cyclades	Cyclades Wireless Network	+
		Heraklion	Heraklion Student Wireless Network	+
		Patras	Patras Wireless Network	+
		Agrinio	Wireless Agrinio Network	+
		Patras	Patras Wireless Metropolitan Networ	+
		Amalias	WANA	+
		Imathia	Imathias Wireless Metropolitan Network	+
		Korinthia	Wireless Network of Korinth	+
		Messina	Messinia Wireless Network	+
		Kefalonia	Kefalonia Wireless Network	+
	Hungary	Budapest	Hungarian Wireless Community	+
	Ireland			+
	Italy	Cerveteri	NOInet	+
		Pisa	eigenNet	+
		Vietri di Potenza	NECO	+
		Rome	ninux.org	YES
	Macedonia	Skopje	Skopje Wireless Community	+
			Macedonian Wireless Community	+
	Netherlands	Leiden	Wireless Leiden	YES
			WirelessVlissingen	+
	Norway	Oslo	Dugnadsnett for alle i Oslo	+

Cont.	Country	Place	Name	Active
	Portugal		Movimento Wireless Português	+
			Unimos	YES
		Moitas Venda	WirelessPT	+
	Serbia	Belgrade	BG Wireless	+
		Novi Sad	NS Wireless	+
		Valjevo	VAWireless	+
		Uzice	Uzice bez zice wireless community	+
		Subotica	SuWireless	+
		Arandjelovac	WirelessAR	NO?
		Kruševac	Kruševac Open	NO
		Titel	Titel Mreza	NO?
	Slovakia		SKFree.Net	+
	Slovenia	Ljubljana	kiberpipa.net	+
			Wlan Slovenija	+
	Spain		guifi.net	YES
			RedLibre	+
	Sweden		Ipredia	N/A
	Switzerland		Openwireless	+
		California	Myrtletown.net (Humboldt County)	+
			NoCatNet (Sonoma County)	+
			Sudo Mesh (Oakland)	+
			Free the Net SF (San Francisco)	+
			SFLan (San Francisco)	+
			Palo Alto Freenet (Palo Alto)	+
			SoCalFreeNet (San Diego)	+
		Georgia		+
			Champaign-Urbana Community Wireless Network (CUWiN)	+
		Illinois	Lawndale Wireless Community Network (Chicago)	+

Cont.	Country	Place	Name	Active
			Wireless Community Networks (Chicago)	UNSURE
		Kansas	Lawrence Freenet Community Network (Lawrence)	+
		Maryland	OpenWiSP (Catonsville)	+
			Maryland Meshnet	+
		Massachusetts	Newbury Open (Boston)	+
		Michigan	DetroitCONNECTED (Detroit)	+
			Detroit Wireless Project (Metropolitan Detroit)	+
			Hot Mesh (Detroit)	YES
			Hillsdale CoolCities (Hillsdale)	+
		Minnesota	USI Wireless (Minneapolis)	+
		Missouri	KC Freedom Network (Kansas City)	+
			WasabiNet (St. Louis)	+
		New Mexico	La Canada Wireless Association (Santa Fe)	+
		New York	NYCwireless	+
			NYC Meshnet	UNSURE
			Public Internet Project	+
			Buffalo Wireless	+
		Oregon	Personal Telco (Portland)	YES
			NetEquality (Portland)	+
		Pennsylvania	PhillyMesh (Philadelphia)	+
			Wireless Philadelphia (Philadelphia)	UNSURE
			PittMesh, Pittsburgh's Wireless Community (Pittsburgh)	+
		Tennessee	ConnectGallatin (Gallatin)	+
		Texas	DFWFreeNet (Dallas)	NO
			Technology-for-All Wireless (Houston)	+
		Virginia	Virginia WiFi Company, statewide umbrella	+
			Richmond Free Wireless (Richmond)	+
		Washington	Seattle Wireless (Seattle)	+
			Seattle Meshnet Project (Seattle)	+

Cont.	Country	Place	Name	Active
		Washington DC	Project Byzantium	YES
			Mount Pleasant Community Wireless Network	+
	Canada	British Columbia	British Columbia Wireless Network Society (BC Wireless)	+
		Saskatchewan	Saskatchewan! Connected	UNSURE
		Ontario	Wireless Toronto	+
			Wireless Nomad	+
			Toronto Wireless Community Network	+
		Québec	Île Sans Fil (Montreal)	+
			ZAP Bas-Saint-Laurent (Rimouski)	+
			ZAP Québec	+
			ZAP Sherbrooke	+
			Centre du Québec Sans Fil (Drummondville)	+
			Montérégie Sans Fil (Brossard)	+
			Laval Sans Fil (Currently under construction)	N/A
			Ottawa-Gatineau WiFi	+
			Réseau Libre Montréal	YES
		New Brunswick	Fred-eZone (Fredericton)	+
		Nova Scotia	Chebucto Community Network (Halifax Regional Municipality)	+
South America	Argentina	Buenos Aires	BuenosAiresLibre	+
		Mendoza	Mendoza Wireless	N/A
		Córdoba	Proyecto Fernets	+
			AnisacateLibre	YES
			QuintanaLibre	+
		Rosario	RosarioSinCables	NO?
			LUGRo-Mesh	+
	Brazil	São Paulo		+
			Rede Mesh Novo Hamburgo	+
	Colombia		Bogota Mesh	YES

Cont.	Country	Place	Name	Active
			Altred	N/A
			Red Inalambrica Comunitaria de Bogota	N/A
		Montevideo	MontevideoLibre	NO?
	Uruguay	Canelones	Proyecto Aurora	N/A
		Tacuarembó	Inchal	N/A
		Luque	LuqueWireless	N/A
	Paraguay	Asuncion	WirelessPY	N/A
	Chile		LicaNet	YES

Table A.1: List of Community Networks or similar known, currently active or not.

Name	Location	Active (years)	#Nodes	#Users	#Active partcp	Env.	Socio-econ Env
Kansas City Freedom Network [2]	Kansas city, MO, USA	3.5	100	600	15	Urban	Developed
DeltaLibre [3]	Delta de Tigre, Argentina	4.5	70	200	20	Rural	Developing
QuintanaLibre [4]	José de la Quintana, Córdoba, Argentina	5	53	250	10	semi-rural	Developing
Berliner Freifunk Community [5]	Berlin, Germany	14	400		100	Urban	stable
Seattle Community Network [6]	Seattle, WA, USA	22	1	500	20	Urban	Developed
Athens Wireless Metropolitan Network [7]	Athens Greece	14	3000	5000	800	Urban	Developed
Wireless België [8]	Belgium	12	700	5000	25	Urban	Developed

[2] http://kcfreedom.net
[3] http://deltalibre.org.ar
[4] http://quintanalibre.org.ar
[5] http://berlin.freifunk.net
[6] http://www.scn.org
[7] http://www.awmn.net
[8] http://www.wirelessbelgie.be

Name	Location	Active (years)	#Nodes	#Users	#Active partcp	Env.	Socio-econ Env
Chiang-Rai MeshTV [9]	Huay Khom village, Mae Yao sub-district, Muang district, Chiang Rai, Thailand.	2.5	40	120	40	Rural	Developing
TakNET [10]	Thai Samakhi village, Mae Sot district, Tak, Thailand	3.5	20	60	30	Rural	Developing
Zenzeleni Networks (Mankosi CWN) [11]	Mankosi AA, Nyandeni Local Municipality, Eastern Cape Province, South Africa	3	13	1000	10	Rural	Developing
Ninux-Firenze [12]	Firenze, italy	4	25	15	10	Urban	Developed
guifi.net [13]	Agnostic (mostly Catalunya, València)	13	25000	60000	200	all	
Sarantaporo.gr [14]	Sarantaporo and surounded villages - Central of Greece	6	153	5000	65	Rural	Developing agricultural economy
Wireless Leiden [15]	West of The Netherlands	14	120	4000	30	both urban and rural	Developed
Cybermoor [16]	UK, Cumbria	14	15	300	500	Rural	Developed
wlan slovenija - open wireless network of Slovenia [17]	Slovenia	8	400			mixed	Developed
ninux.org Roma [18]	Rome, Italy	13	172		35	Mainly urban	Developed

[9] http://www.interlab.ait.asia/ChiangRaiMeshTV
[10] http://www.interlab.ait.asia/TakNet
[11] http://zenzeleni.net
[12] http://www.firenze.ninux.org
[13] http://guifi.net
[14] http://www.sarantaporo.gr
[15] http://www.wirelessleiden.nl
[16] http://www.cybermoor.org
[17] http://wlan-si.net
[18] http://wiki.ninux.org

Name	Location	Active (years)	#Nodes	#Users	#Active partcp	Env.	Socio-econ Env
Bogota Mesh [19]	Bogota - Colombia	5	17		10	Urban	Developing

Table A.2: Replies from several CN contacted: general aspects.

Name	Infrastructure	Membership	Types of Members	Legal Form	Funding	Inet Provision
Kansas City Freedom Network	Wireless Mesh, Wireless Point-to-Pont, Fibre, Wireless Access Points	Community-License Based, Contribution Based	Volunteers, Professionals, Companies, Service Providers, Government	None	Members, Public Institutions, Private Institutions	Uplinks from Tier 2&3 ISPs
DeltaLibre	Wireless Mesh, Wireless Point-to-Pont, Wireless Access Points	Informal, Contribution Based	Volunteers, Professionals, NGOs	None	Members	Uplinks from Tier 2&3 ISPs
QuintanaLibre	Wireless Mesh, Wireless Point-to-Pont, Wireless Access Points, wired ethernet (<100m).	Informal, Contribution Based	Volunteers, Academic	Formal org	Members, current bandwidth is provided free of charge by a company in the local Internet Exchange	Uplinks from Tier 2&3 ISPs, DSL Sharing
Berliner Freifunk Community	Wireless Mesh, Wireless Point-to-Pont, Fibre, Wireless Access Points	Anonymous, Informal, Contribution Based	Volunteers, Professionals, Companies, Service Providers, Government, Academic	None, Formal org, Registered as network/telecom operator	Members, Public Institutions, Private Institutions	Uplinks from Tier 2&3 ISPs, DSL Sharing
Seattle Community Network	Web and dialup	Fee Based, Contribution Based	Volunteers, Professionals, Academic	Tax exempt 501.c.3 us corp.	Members	Through public library

[19] http://www.bogota-mesh.org

Name	Infrastructure	Membership	Types of Members	Legal Form	Funding	Inet Provision
Athens Wireless Metropolitan Network	Wireless Mesh, Wireless Point-to-Pont, Wireless Access Points	Fee Based	Volunteers	Formal org	Members	Uplinks from Tier 2&3 ISPs, DSL Sharing
Wireless België	Wireless Mesh, Fibre, Wireless Access Points	Informal, Fee Based	Volunteers, Professionals, Companies	Formal Company	Members, Companies who use us for internet access	Uplinks from Tier 2&3 ISPs
Chiang-Rai MeshTV	Wireless Mesh, Wireless Point-to-Pont	Informal, Contribution Based	Volunteers, Professionals, Academic	None	Private Institutions, ISIF Asia and THNIC Foundation	5 Mbps uplink at the Mirror Foundation
TakNET	Wireless Mesh	Contribution Based	Volunteers, Academic	None	Members, Private Institutions, THNIC Foundation	DSL Sharing
Zenzeleni Networks (Mankosi Community Wireless Network)	Wireless Mesh	Anonymous previously. VoIP services only for members of the coop. Fee based, but fee automatically converted into service airtime	A partnership between UWC, the village, local NGO, local school	Formal network and telecom operator	Members, Public Institutions, UWC provided the initial capital, members are covering the running costs	No Internet Provision, Public Phones using VoIP via 3G
Ninux-Firenze	Wireless Mesh, Wireless Point-to-Pont	Informal	Volunteers	None	Members	No Internet Provision
guifi.net	Wireless Mesh, Wireless Point-to-Pont, Fibre, Wireless Access Points	Community-License Based	Volunteers, Professionals, Companies, Service Providers, Government, Academic	Foundation	Members	Uplinks from Tier 2&3 ISPs, ISP and RIPE-NCC member
Sarantaporo.gr	Wireless Mesh, Wireless Point-to-Pont	Anonymous	Volunteers, Professionals, Academic	Non Profit Organization	Members, European Union Research Programs	DSL Sharing

Name	Infrastructure	Membership	Types of Members	Legal Form	Funding	Inet Provision
Wireless Leiden	Wireless Mesh, Wireless Point-to-Pont, Mobile, Wireless Access Points	Informal	Volunteers, Professionals	Formal	Members, Public Institutions, Private Institutions	Uplinks from Tier 2&3 ISPs, DSL Sharing
Cybermoor	Wireless Point-to-Pont, Fibre, Wireless Access Points	Fee Based	Volunteers, Professionals, Companies	Formal	Members, Public Institutions, Private Institutions	Uplinks from Tier 2&3 ISPs
wlan slovenija	Wireless Mesh, VPN over service providers	Anonymous, Informal	Volunteers, Professionals, Academic	None	donations for core infrastructure	Uplinks from Tier 2&3 ISPs
ninux.org Roma	Wireless Mesh, Wireless Point-to-Pont, Wireless Access Points	Informal, Community-License Based	Volunteers, Professionals, Academic	None	Members	Uplinks from Tier 2&3 ISPs, DSL Sharing
Bogota Mesh	Wireless Mesh, Wireless Point-to-Pont	Anonymous, Informal	Volunteers, Professionals, Academic	None	Members, Donations	DSL Sharing, No Internet Provision

Table A.3: Replies from several CN contacted: specific organisational aspects.

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