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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 with a few of the most representative Community Networks (CNs) and more relevant, one way or another, to the netCommons project. The next release of the deliverable in M9 will include more CNs in the analysis and also extended classification and insight.

The report first of all review 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, and Sarantaporo.gr, that are so far the closest to netCommons and those with whom we already have contacts and are conducting field work and cooperation. have inspired the development of the general framework; An extensive list of many self-proclaimed CNs around the world and their rough organizational models closes this descriptive part of the Deliverable.

The final part is devoted to a first comparison and classification of different models. The next WP1 deliverable (D1.2) in M9 will add more CNs and more details in the analysis, laying the foundations for the more theoretical work in WP4 and WP5.

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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
ICT	Information and Communications Technology
ISM	Industrial Scientific Medical
ISP	Internet Service Provider
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 Introduction

This deliverable provides a mapping of Community Networks CNs around the world, with a 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. The next release of the deliverable (D1.2) in M9 will include more CNs and more details in the analysis. The report is organised as follows:

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) that have inspired the development of the general framework;

d) An extensive list of many self-proclaimed CNs around the world and their organisational models;

e) A comparative analysis of different CNs, coupled with a discussion.

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 [2] 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. 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) will be issued."*

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

1.1 Network infrastructures

According to [3] 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 to provide 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, involving 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 fruition reducing the time needed to obtain the service and allowing service fruition outside normal business hours.

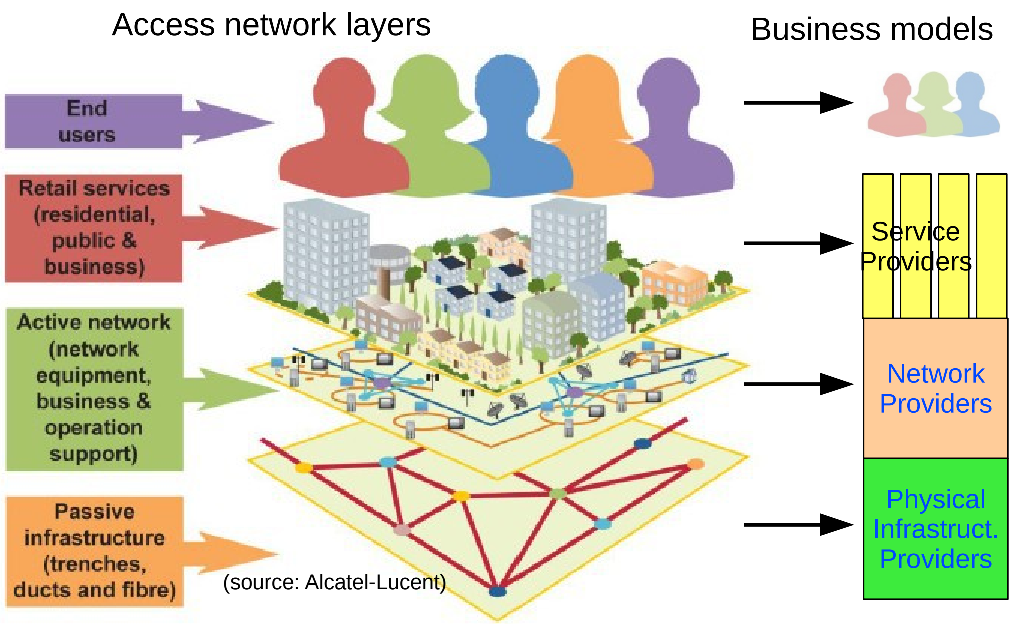

Figure 1.1: The components of a broadband network (with a focus on optical fiber) and the three service layers.

According to the broadband[3] investment guide of the European Commission [4] and supporting research [5], the structure of a modern network service consists of three inter-dependent layers: a) the

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

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) [6] 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 fiber, 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 virtualization 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 [4]. This has been recognized as a critical challenge by ITU in a report [7] 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 fiber backbones: open access to bottleneck or essential facilities (like fiber 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 divi-

sions;

- 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) [8].

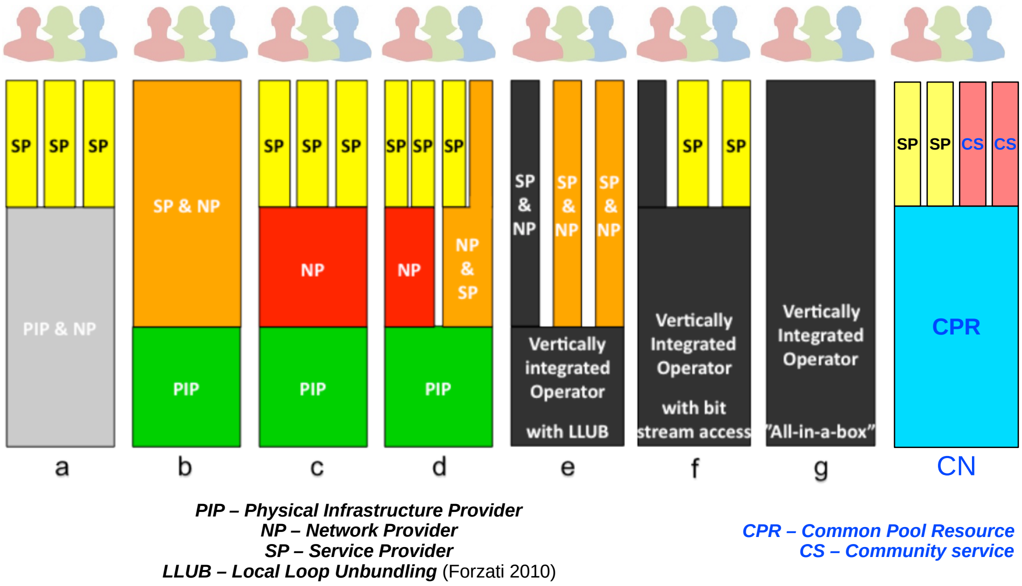

Figure 1.2: Different division and separation across the three service layers.

The typical business models of modern data networks typically follow one of the structural models depicted in Figure 1.2. While 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 fiber, international gateways, and even spare Internet connectivity with other members of the community.

2 An Organisational Framework for 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 pleasure or the act of contributing to development of a new telecommunications model 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 [9].

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[1]. 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 [10] is a social enterprise that provides Internet access, electronic commerce, education, telemedicine, environmental. and agricultural services to a number of remote villages, using wireless technologies. French Data Network Federation (FFDN) is a federation of French Do-it-Yourself ISPs which comprises Digital Subscriber Line (DSL) resellers, Wireless Internet Service Providers (WISPs), collocation centres, and the like. HSLnet is one of the many cooperative fiber-optic networks in the Netherlands. All these networks are very diverse in many aspects, and only a careful structural analysis will allow to classify each under one or several models. This is the aim of this chapter.

In Open Access networks (OANs) [11] anyone can connect to anyone in a technology-neutral framework that encourages innovative, low-cost delivery of services to users [7]. In other words: multiple providers sharing the same physical network. In many cases, these 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 [12], having a key socio-economic impact in the region [13].

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, including commercial purposes.

Representative examples[2] 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

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

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

Ninux.org in Italy.

All of them include thousands of links, mostly wireless[3], but gradually integrating also optical fiber and optical wireless links.

Although CNs have already been studied from several angles [14, 15, 16, 17], 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 [18, 19, 20], technological [21, 22, 23] or organisational [1, 24] point of views. However, there is a lack of a common framework to analyse the non-technological aspects of CNs that were key for the initial development of the movement, but that nowadays with a more commoditised and diverse technology options, are replaced by the challenges of organization, and related issues around participation, sustainability, resilience, adaptability, impact, etc. This is the objective of the remaining of this Section.

2.1 Principles

The fundamental principles of most CNs, defined at 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, four main groups can be identified: i) volunteers, interested in aspects such as neutrality, privacy, independence, creativity, innovation, DIY, and 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. A balance among these four groups must be preserved, as every group has natural attributions that should not be delegated or undertaken by any other.

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

A CN is 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 because the participants work cooperatively at local scale, to deploy network islands, and at global scale to share knowledge

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

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 of commons-based peer production in particular, is a reference 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 optimal 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 [25]. 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 [26], 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 [27], 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 [28], infrastructure commons with the example of internet congestion and network neutrality [29], and internet/spectrum commons [30].

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 [31]. 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 [32].

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 [33] 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) [34, 35, 36, 37]. 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 [38] them for the sake of a sustainable circular economy.

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 [39] 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 [40], 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 [41]. 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 ae 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.” [31]

2.3 Stakeholders

A commons is composed by a resource (the CPR), which is governed (according to rules analysed by the commons frameworks) by a community (which can be composed by several types of actors). This section will analyse the various stakeholders, or members of CN, based on their tasks, 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. As depicted in Figure 3.3, there are typically four main stakeholders. The *volunteers*, the initiators of the project, due to their lack of economic interests, 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 [42] 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 [42] for natural resources, results in different access rights, with authorized users (customers) that are given access (connecting) and withdrawal rights (consumption or harvesting connectivity) through services provided by professionals or volunteers to have equivalent rights to manage or govern the infrastructure.

Joining a CNs (access), implies 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 typically 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 less 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 [43], 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.

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 [44], 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. Typically, it 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 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. 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.

Several CNs also act as an Internet eXchange Point (IXP) 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).

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

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

2.4.1 Communication tools

A network infrastructure commons has an important challenge in communications as typically 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[4] 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 (typically weekly or monthly). 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 typically includes:

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)[5]. 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 typically 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 [45] to manage the different components that make up the network infrastructure, configure devices and network elements, reduce errors, facilite 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 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;

[4] 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.

[5] 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 the project has developed to keep the infrastructure and the project itself operational. Typically there are tools for a) *Conflicts resolution*, with 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 Services

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, 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 providers, citizens sharing their unused Internet access capacity with neighbours and friends, public or private organisations offering a limited Internet access for 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[6].

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.

2.4.6 Sustainability

Analysing the design of long-enduring CPR institutions, Ostrom [25] identified eight principles, which are prerequisites for a sustainable CPR. We now discuss their application to these human-made resource systems that provide connectivity:

[6] Checked against the National Markets and Competition Commission, Spain

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 typically 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.

2.4.7 Adaptability - Adaptable Governance

The concepts and governance tools of CNs relate to what Ostrom [46] 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. The 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 Impact

Typical measures such as geographic spread, number of nodes and locations, number of actual and reachable participants, km of links help to quantify the coverage and service a CN is providing.

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 [26]. 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 [47].

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. Typical 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 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.

A look ahead: Sections 2.2 and 2.3 studied CNs as a CPR governed by stakeholders. Our next step for M9 version of this deliverable will be to extend the analysis by using parts of the frameworks developed for other types of commons, and to propose a refined working definition of CNs as a commons.

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 guifi.net

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 [25], that is to say, to protect it from the *Tragedy of the commons* [48]. 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.

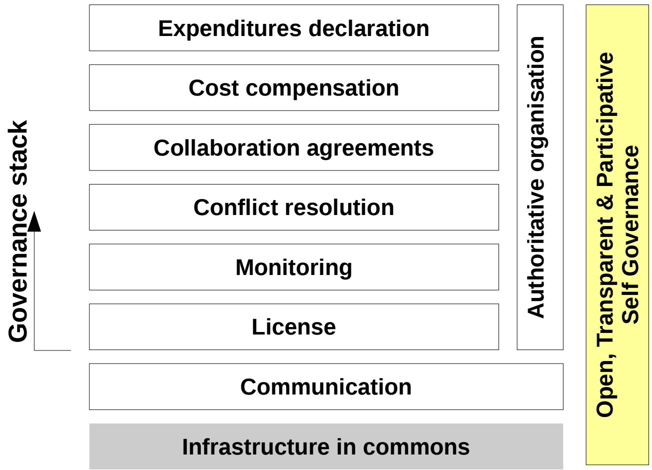

Figure 3.1: Governance tools (based on [1]).

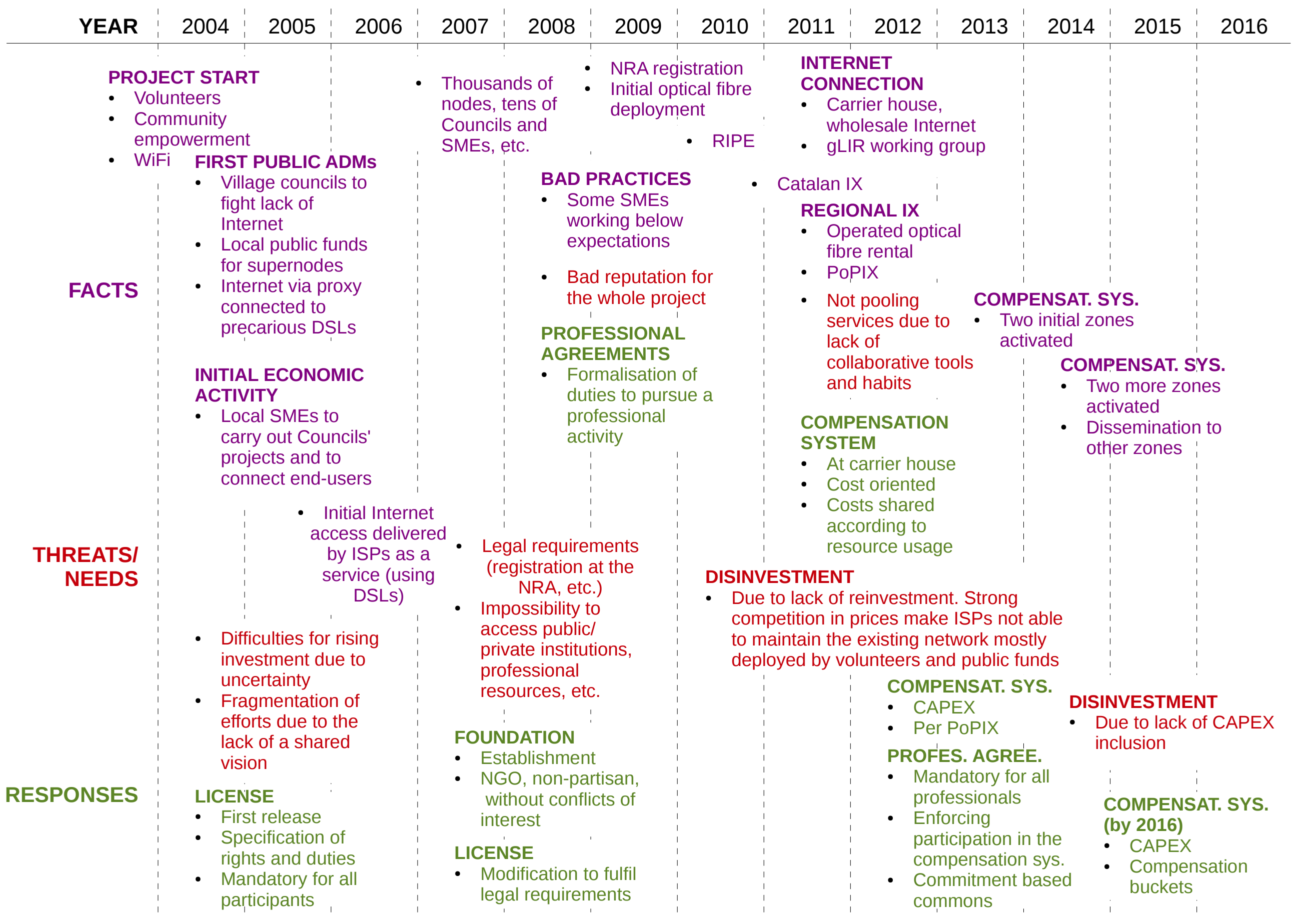

Figure 3.2: Facts, threats, and responses over time.

3.1 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 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.

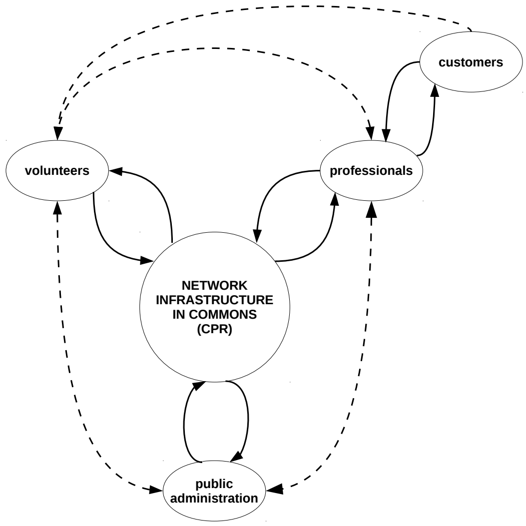

Figure 3.3: Stakeholders.

3.2 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 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 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.

3.3 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

[1] http://en.wiki.guifi.net/wiki/CNML/en
[2] https://llistes.guifi.net/sympa/
[3] http://social.guifi.net/
[4] http://guifi.net/en/FONNC.

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 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).

[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.*

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.

3.4 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 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.

3.5 Implementation 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

[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).

[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.

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).

In terms of network and application services, there are many announced services: 10 direct Internet gateways, 310 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.

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 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)[10] [49] show 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.

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

4 Organisational Elements of FFDN

This section presents FFDN,[1] 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 [50], 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.

4.1 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[2] 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[3], its internal rules[4] (*règlement intérieur*) and its Charter of good practices and common commitments[5], 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." 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

[1] https://www.ffdn.org/.
[2] https://www.ffdn.org/en/members-fdn-federation
[3] https://www.ffdn.org/en/members-fdn-federation
[4] https://www.ffdn.org/fr/reglement-interieur
[5] https://www.ffdn.org/fr/charte

Internet networks as a commons.[6]

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[7]). 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.

4.2 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).

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

[6]On FFDN's commons framing, see also section 4.6.

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

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[8]. 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[9]. 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.

4.3 Services

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] 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).

[9] 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.

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 Owncloud or a PirateBox for local file-sharing.[10] 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[11].

4.4 Tools

4.4.1 Network and provisioning tools

Software tools for network management and provisioning

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[12], it helps map out the best 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).

[10] See https://internetcu.be/ and https://yunohost.org.
[11] http://www.indecp.org/
[12] See https://code.ffdn.org/ffdn/wifi-with-me.

IPs assignment and routing configuration For IP assignment, FDN wrote its own piece of code for an automatized and web-facing system administration: COIN[13]. 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.[14] 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.

4.4.2 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.

Wikis If websites are usually poorly maintainted, wikis 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

[13] `https://code.ffdn.org/FFDN/coin/`.

[14] 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.

debated, one for the board. Some mailing-lists are created for specific working groups (on regulatory or technical issues).[15]

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.

4.5 Participation framework

All FFDN members have been created as *associations* under the Law of July 1st 1901 on the freedom of association.[16] 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.

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

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

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

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.

4.5.1 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."

4.6 Implementation 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 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 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 technical 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).

5 Organisational Elements of Ninux

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.

5.1 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) [1].

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.

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.

5.2 Implementation

Ninux is a Wi-Fi mesh network, implemented with standard wireless router equipped with custom firmware.

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

The Ninux network is composed of several islands spread around the Italian peninsula. 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;
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 5.1 to a roof switch, that is then connected with only one cable to the ground router).

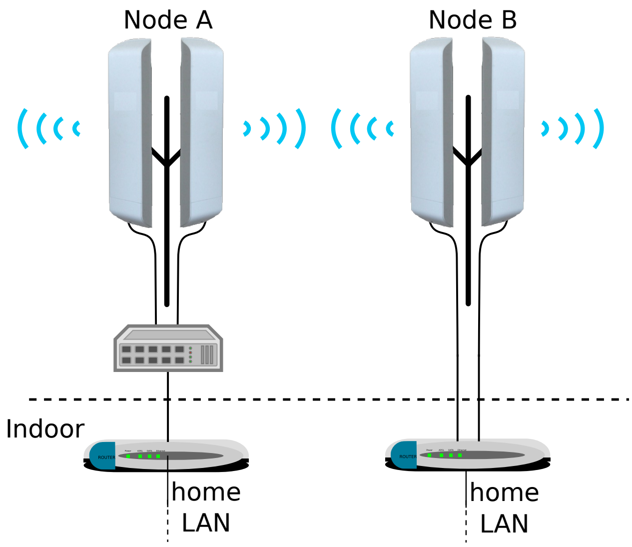

Figure 5.1: A wireless node configured for ground routing.

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 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.

5.3 Communication Tools

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

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[2]. Some of the pages are translated in English, but the language is primarily Italian.

Blog: the community also has a blog[3], 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[4] 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[5]. 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.

5.4 Impact

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.

[2] http://ninux.org
[3] http://blog.ninux.org
[4] http://map.ninux.org
[5] http://map.nodeshot.org

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 5.2.

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[6].

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[7] 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, 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.

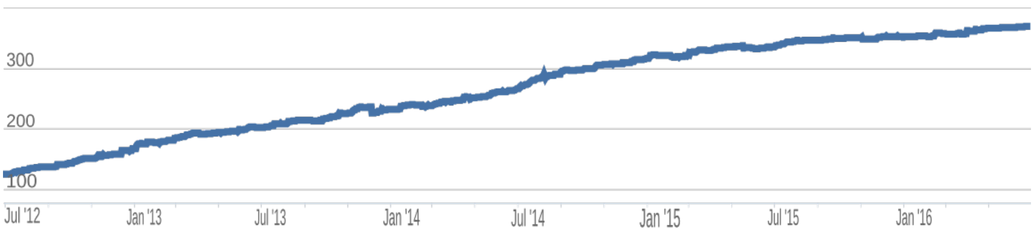

Figure 5.2: The growth of the Ninux network in the last 4 years: June 2012 - June 2016.

[6] http://wiki.ninux.org/Stampa(inItalian)
[7] http://netjson.org

6 Organisational Elements of Sarantaporo.gr

Sarantaporo.gr is a community network which connects 14 villages in the rural area of Elassona, in the north-west part of Greece. Poor access to or lack of basic telecommunication services due to non-existing network infrastructure was the main reason that lead to the development of this community network. Due to the geographic position and the small population of villages, telecom operators had not invested in the area until quite recently. Hence, the locals did not have access to the internet and ensuing services of ICT technologies.

The core team of Sarantaporo.gr began its action in 2010. A group of people got together on a voluntary basis and started creating a wireless community network that provides access to broadband services for local residents, local institutions,groups and visitors of the area. The installation of the equipment for the wireless network started first from the village of Sarantaporo and expanded gradually to nearby villages 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, and the EU project CONFINE, for the backbone. But today, every village has to cover the costs of maintenance and all the additional equipment installed.

In its current status, the network connects all 14 villages through a single communication infrastructure and provides access to its network services. From its very beginning it started with the goal of boosting the socio-economic development of this under-served agricultural area and is aimed at creating the circumstances needed for cooperation with other potential stakeholders.

The community network is characterized as public, open and social in the sense that:

- It is implemented and developed by the core team along with contributions of local groups and active residents of the area;
- It is 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;
- There is no profit incurred from the access to the community network.

The community network Sarantaporo.gr is commons, i.e. a resource open to all and manageable by all those involved in it. It 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 the wealth of knowledge and opportunities it offers.

6.1 Stakeholders

Non-profit civil partnership: Sarantaporo.gr has been established as a non-profit civil partnership in 2013. It involves the group of people who started in 2010 plus additional members who were interested in joining the effort over time. Following the legal framework around non-profit Organizations, the partnership complies with a set of articles of the association. Any change in the membership has to be made according to the legislation.

Partners: External partners can be volunteers that provide their help with preserving or extending the network infrastructure or economic contributors like local groups. Local groups may refer to local cultural associations or any kind of group formed within the village with the objective of collaborating with Sarantaporo.gr. Part of their role involves the gathering of contributions for the monthly fee aimed to cover the operational and expansion expenses of the network. Another type of partner involved is the Greek FOSS society which provided the majority of the initial equipment for building the separate access networks within the villages. Also, the Technological Educational Institute (TEI) of Thessaly is a partner that provides internet connection to Sarantaporo.gr.

Professionals: These are companies or small businesses that provide services over the network. The integration of professionals to the network is a recently inserted idea. There are examples of companies that can provide VoIP services and sensor monitoring.

Users: Residents able to have access to the network. Some of them have installed network equipment on their houses while others access the network with their end-user devices. The residents contribute economically with a monthly fee (60 Euros/village), but there are also people that use the network and do not contribute (namely free riders).

6.2 Services

The remote agricultural area where Sarantaporo.gr has been deployed, faces different kinds of problems such as the poor access to infrastructure and equipment, the physical distance from large cities, high prices for raw materials in the primary sector due to lack of information, unawareness of agricultural market demand, etc. Services and tools provided by the community 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: is one of the most popular services used by the local residents and users of Sarantaporo.gr. People have 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 the community network, the access to such available information was limited and their choices where dependable on few local intermediaries that could exploit their monopoly at the expense of the producers' profits.

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

Video streaming: of important community events. It can be used upon demand and collaboration with the core team of the network. Video streaming can also be used for tutoring in cases that schools are not easily accessible or for training people regarding their profession or the use of ICT technologies.

Monitoring: Locals may use monitoring tools for their farms or local businesses. 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 community network can save professionals and producers from spending valuable time and economic resources.

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

6.3 Implementation and impact

The effort of Sarantaporo.gr has created a modern telecommunication infrastructure that is available to local communities of the area, managed and operated by its own users. For the time being, quality indexes show 14 villages with access to Sarantaporo.gr network, 22 nodes installed for the backbone network and 160 nodes in the access network. The network is able to serve a total amount of 5,000 people who are permanent residents and 3,000 other people that are benefited directly or indirectly. The amount of traffic moved around the network reaches 5.5TB on average and the maximum speed of accessing the network is 30 Mbps for download and upload links.

In the last 5 years, several benefits have been brought to the community such as: a) reduction of the cost of living by reducing the costs for moving and providing access to e-commerce of products and services, b) reduction in raw materials cost in the primary sector, c) increase of profits for producers due to their ability of accessing a variety of buyers, d) remote medicine subscription that is a crucial matter in under-served areas for the whole of the community and especially for the elderly. Apart from providing the telecommunication infrastructure, the core team of Sarantaporo.gr organizes cultural and educational activities aiming to confront the digital divide and train people in new technologies, and finds solutions for the primary sector aiming at ameliorating people's everyday life via the use of ICT.

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 be benefited by its use while adding to its expansion. The types of local services offered are to be deployed for the wide range of network users along with the corresponding training needed. Moreover, the Sarantaporo.gr core team aspires to create an efficient business model for the Sarantaporo.gr but with a framework generic enough to be made applicable to other similar under-served areas as well.

The current description of Sarantaporo.gr is under development and there are ongoing interactions with the local communities. In D1.2 it will be extended and formalised according to the framework in Section 2 in a more detailed mapping.

7 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 network (a loose and informal interconnection of routers), a community network (as defined in 2), a top-down ISP (such as Wireless ISP or WISP, for profit or not), or a municipal network (run or managed by a municipality or other governmental organisation), among several other models.

Table 7.1 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 seem inactive, 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 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 find out complementary information through the social network of contacts between different community networks.

As a result of a survey, we collected details about several 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 7.2 and Table 7.3.

[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	+
		Celkovice	Czela.net	+
		Hradec Králové	HKFree.org	+
		Kladno	KLFree.Net	+
		Liberec	LBCFree.net	+
		Plzen	PilsFree.net	+
		Unhošt	UNHFree.net	+
		Kutná Hora	KHnet.info	+
		Mnichovo Hradiště	mh2net	+
		Ostrava	Evkanet	+
		Prague	CZF-Praha	+
		Křivonet	Krivonet	+
		Prague	JM-Net	+
		Slavičín	SLFree.Net	+
		Varnsdorf	Gavanet	+
		ACzW	AirDump.Net	+
		Holov	NobodyNet	+
		Prostejov	PVFree.Net	+
			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
	Germany		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	+
		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		+
		Illinois	Champaign-Urbana Community Wireless Network (CUWiN)	+
			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
	Paraguay	Luque	LuqueWireless	N/A
		Asuncion	WirelessPY	N/A
	Chile		LicaNet	YES

Table 7.1: List of Community Networks 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] 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 Community Wireless Network) [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 WiFi Community Networks [14]	Sarantaporo and surounded villages - Central of Greece	6	180	1700	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] www.firenze.ninux.org
[13] http://guifi.net
[14] www.sarantaporo.gr
[15] http://www.wirelessleiden.nl
[16] 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 7.2: 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	on the web or dialup	Fee Based, Contribution Based	Volunteers, Professionals, Academic	A tax exempt 501.c.3 corporation in the US	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	It has been anonymous to date. From now on, for using the VoIP services they need to become members of the cooperative. It is fee based, but the fee is automatically coverted into airtime for the service.	So far, it has been a partnership between UWC, the village, and a local NGO. The local school has recently joined.	network/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

Name	Infrastructure	Membership	Types of Members	Legal Form	Funding	Inet Provision
Sarantaporo.gr WiFi Community Networks	Wireless Mesh, Wireless Point-to-Pont	Anonymous	Volunteers, Professionals, Academic	Non Profit Association	Members, European Union Research Programs	DSL Sharing
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 7.3: Replies from several CN contacted: specific organisational aspects.

8 A comparative analysis and 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 but quite rival when implemented and deployed in communities, are always at the brink of congestion. While 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), CNs have developed institutional tools to handle sustainability and resilience of these infrastructures to balance contribution and consumption, more participants with more connectivity resources and wider reach.

Typically there is a clear 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 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. 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 commercial or just 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 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.

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).

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).

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.

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 professionalization, but that may have also transformational effects on the structure of these initiatives.

Several of the key factors are represented in Table 8.1 that allow a comparison of the different features.

Community	Scale	Commons-based governance	Legal representation	Infrastructure	Economic model	Licensing model
Guifi	4 zones in Africa, 16 in America, 2 in Asia, 14 in Europe (Countries), 21 provinces in Spain, and for instance 41 counties in Catalonia	Mixed (decentralized at local level but strong commons-based governance at level of Guifi.net foundation). Related groups organising 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) + centralized last-mile?	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
Santaporo						

Table 8.1: Comparative table of main European CNs

9 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 communicate in the artificial digital space as we can do in the natural acoustic space. These artificial material commons are critical enabling infrastructures for the digital world. These infrastructures enable self-provisioned and self-organized ways to build and ensure social connection and access to knowledge, content, communication. As the report shows, diversity makes a difference, and local CNs have created local institutions or organisational structures adapted to local conditions and needs, with different levels of sophistication. Each initiative is adapted to localities, with slightly different starting points, goals, strengths and weaknesses, and diverse levels of development and structuring.

The theory of the commons allows us to look at the design and experiences of several CNs from multiple perspectives. We have looked at resilience and sustainability in a common property regime, its incentives and compensation 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. The 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. The research activities like this one adds to resilience and adaptability.

Future work (D1.2) will include the analysis additional community networks, at least the most representative of mostly WiFi enabled networks such as Freifunk (DE), AWMN (GR), and optical fibre enabled too.

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