

# On an Ecosystem for Community Cloud Services in Guifi.net

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No Institute Given

**Abstract.** Community networks build and operate local IP-based networks. They originated as communication infrastructures developed by citizens that enabled isolated communities to connect to the Internet, in order to be able to participate in the daily usage of Internet services. Community networks showed that network services can be built and maintained in a collective action. This paper looks into the question if the lessons learned in terms of tools and instruments from community network operation can be applied to have cloud-based services offered within community networks. Such local cloud-based services could offer to users and providers new features which differ from those of current cloud service offers in the Internet.

**Keywords:** incentive mechanisms, cloud computing, community networks, distributed resource sharing

## 1 Introduction

Community networks, also known as bottom-up-broadband networks, consist of a communication infrastructure in which local communities of citizens build, operate and own open IP-based networks. Community networks often originated as a solution to give Internet access to populations in areas which were unattended by commercial telecom operators.

Community networks are a successful case of resource sharing among a collective, where resources shared are not only the networking hardware but also the time, effort and knowledge contributed by its members, required for maintaining the network. Hundreds of community networks operate across the globe, in rural and urban, rich and poor areas. In Europe, several community networks operate since more than ten years, like Freifunk in Germany, FunkFeuer in Austria and AWMN in Athens, Greece. A few only have achieved to become really large. Among them is Guifi.net in Spain, which has reached in 2015 more than 25000 nodes.

While community networks have evidenced that fact that a communication network can be achieved by the collective action of people, it is now of interest if the ecosystem and principles upon which the community networks operate, can be extended to the next step, to cloud-based service provision by communities.

Such local cloud-based services could offer to users and providers new features, which are not given (and some are not possible to be given) by the current

dominating cloud service providers in Internet. The potential lies therefore in the application of the concept of the community cloud to the communities of citizens [1]. A community cloud in its generic form refers to a cloud deployment model in which a cloud infrastructure is built and provisioned for an exclusive use by a specific community of consumers with shared concerns and interests, owned and managed by the community or by a third party or a combination of both [2]. Commercial community cloud solutions are a reality nowadays and are deployed in several application areas with specific requirements (e.g. security, performance), such as in the financial, governmental and health sector.

We argue that a community network cloud, a cloud infrastructure formed by community-owned computing and communication resources able to provide services of local interest, can happen if the appropriate tools and mechanisms are in place.

In this paper, we present an incentive mechanism tailored to community networks. The main contributions of this paper are the following:

1. A review of the sustainability model that is applied in the Guifi.net community network and that has achieved to maintain and the growth of the network.
2. A framework for establishing and maintaining cloud-based services in Guifi.net.
3. Cloud-based service provision in Guifi.net and and assessment of its performance.

We elaborate our contributions in the following way: In section 2 we present the ecosystem, which is applied in Guifi.net to the maintenance of the network infrastructure. In section 3, we extend the lessons learnt to a framework for cloud-based service provision. In section 4 we describe how the framework has been implemented and analyze several performance indicators, as well as discuss open issues. In section 5 we conclude our findings and indicate future work.

## 2 Elements of the Guifi.net Ecosystem

### 2.1 Coexistence of voluntarism and economic activity

Guifi.net is a success case for the coexistence of voluntarism and a solid economic activity. Project steering tasks are part of the voluntary community activity, while the professional community takes care of attending the service demands. Governance tools play a critical role in keeping the voluntary-professional relationship balanced. The equilibrium is critical for the sustainability of the project, because, although the economic sustainability is fundamentally based on the revenue generated by the commercial activities, the governance and the harmonisation of the ecosystem as a whole is mostly made by the volunteers.

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 the services delivered over the network. Infrastructure services are possible because while people have the right to carry out tasks on their own,

there is also the possibility to obtain the services of professionals, who must nevertheless abide the community rules. Although Internet access is still the most popular service, others such as VoIP and remote backups have also been offered for a long time. New services such as video streaming and video on-demand are becoming popular, specially in the areas served by optical fibre. The professionals offering infrastructure services are commonly referred as *installers* and content providers as *operators*. These activities are typically done by self-employed individuals and SMEs that frequently combine installer and operator activities. Most of the professionals perform volunteer activities as well.

Similar to the balance that must be found between volunteers and professionals, a balance among professionals is also needed because although they can compete for customers, they must coordinate and collaborate since they are using a shared infrastructure to reach their customers. A system with several type of agreements based on the level of commitment with the commons and an economic compensation system for the investment and resource consumption are the pillars of this collaboration.

The guifi.net Foundation (Fundaci Privada per a la Xarxa, Lliure i Neutral guifi.net) is the reference organisation that was founded by the guifi.net community. As such, it plays a vital role for the coordination and management of the guifi.net ecosystem. Nonetheless its power is rather limited 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. Thus, its authority is mostly reputation based.

## 2.2 Network infrastructure is a Common Pool Resource

Guifi.net manages the network as a common pool (CPR) [3], being the network infrastructure the core resource. The network segments, which the participants deploy to reach the network or to improve it, increase the network, and the reward is the connectivity they get. Holding the infrastructure in commons has immediate effects such as the avoidance of the multiplicity of infrastructure because all participants operate on the same one, the increase of the efficiency of the infrastructure and costs savings, also environmental, for the same reason, etc.

For commercial services these effects are very positive and translate into a reduced entry barrier. The knowledge about the network is open (no hidden knowledge). The network is neutral: There are no frameworks in operation that artificially limit the scope of service creations.

However, community networks, as other CPR, are fragile. Specifically, they are congestion prone, because connectivity is shared, and therefore subject to the free-rider problem. Therefore, efficient and effective governance tools are needed to protect the core resource from depletion, that is to say, to protect it from the *Tragedy of the commons* [4]. The network license or the conflict resolution procedure are examples of the tools we have employed.

Collaboration tools and public information sets must also be in place to make the CPR viable. Aside from the standard mailing list 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 service deployed. However, they can be needed for the commercial enterprise being able to offer service level agreements (SLAs) for the services they offer to the customers.

## 2.3 Tools and Components

This section describes the tools and components that, to our understanding, play a critical role in the guifi.net ecosystem.

**Network management and provisioning software tools** 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 into the guifi.net website<sup>1</sup>. All these tools are publicly available as free software. Automation is essential to reduce the learning curve and to avoid human mistakes. Public information sets are essential to make the network implementable.

**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.

**IPs assignment 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<sup>2</sup> is an XML specification developed in guifi.net through which guifi.net database information is presented. All interactions should be done through it.

**Network monitoring** A fully distributed network monitoring system has been developed and implemented. It has been key to help the community to 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

<sup>1</sup> The guifi.net website uses Drupal as CMS and MySQL as database. All the developed tools are presented as Drupal modules.

<sup>2</sup> <http://en.wiki.guifi.net/wiki/CNML/en>

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.

**Participation tools** There are many means of participation. The following are the most significant ones.

**Grup LIR (GLIR)** It is the technical group in charge of operating the guifi NOC. It consists mostly of professionals, but volunteers also have the right to participate. The group is closed to protect sensitive information.

**Mailing lists** Mailing lists<sup>3</sup> it is one of the most used communication means. There are global, territorial and thematic mailing lists. They are open by default<sup>4</sup>.

**Social Media** A social platform<sup>5</sup> has been put in place 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 are usually weekly or monthly based. A global guifi.net community meeting usually happens once a year, it is itinerant and always hosted by a different local group. In addition, at least one or two guifi.net members attend the most important international events.

**Network Commons License (NCL)** NCL<sup>6</sup> is the license which every guifi.net participant must subscribe. Its preamble<sup>7</sup> sets the fundamental principles and the

<sup>3</sup> <https://l1listes.guifi.net/sympa/>

<sup>4</sup> Closed mailing lists are just accepted in very justified situations.

<sup>5</sup> <http://social.guifi.net/>

<sup>6</sup> <http://guifi.net/en/FONNC>. *Llicència de Comuns per a la Xarxa Oberta, Lliure i Neutral (XOLN)* in Catalan <http://guifi.net/ca/CXOLN>

<sup>7</sup> 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.*

articles precisely establish the participants rights and duties. It is written to be enforceable under the Spanish legislation. Legal certainty is essential to stimulate participation and investment, which in turn, is at the base of any economic activity. 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.

**The Foundation** The guifi.net Foundation aims at giving a legal identity to guifi.net. Its foundational mission is to protect and promote the network held in commons. As part of protection actions, it maintains the FONN Compact 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, who need them to expand the network. It also does many dissemination activities. The Foundation is composed by the Board of Directors (unpaid) and the workers. It is funded from the services it gives to the professionals (e.g. activities in the Network Operation Center (NOC), operation of the economic compensations system) and from specific projects to which it may participate (e.g. research projects, consulting activities).

**Collaboration agreements** Collaboration agreements are aimed at strengthening the legal certainty derived from the NCL. These agreements result from the experience of many specific agreements over the years. Nonetheless, the set of agreement models must remain manageable.

**Professionals** Any professional who wants to carry out economic activities involving guifi.net infrastructure must sign a professional agreement with the Foundation. As part of the agreement, the professional must state its level of commitment to the commons. There are three options, *type A*, all the infrastructure deployed by the professional is contributed to the commons, *type B*, a part of the professional infrastructure is contributed to the commons, and *type C*, the professional does not contribute any infrastructure to the commons (that is to say, they use what is available but does not contribute at all). The agreement implies the acceptance of a set of Service Level Agreements (SLAs) aimed at facilitate the coexistence among the professionals. Once the agreement is signed, the professional is included in the economic compensations system and is allowed to benefit from the Foundation tools for operators (e.g. wholesale Internet access, Local Internet Registry, Internet eXchange point participation).

**Third parties** The Foundation also establishes agreements with third parties such as public administrations, private companies or universities. Through these agreements public administrations eschew their legal limitations to participate in telecommunication activities and limit responsibilities which

fall outside of the scope of their standard tasks, specially for small and middle size administrations<sup>8</sup>. 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.

**Conflicts resolution system** A systematic and clear procedure for resolution of conflicts with a scale of graduated sanctions has been developed<sup>9</sup>. It consists of three stages, conciliation, mediation and arbitration, all of them driven by a lawyer chosen from a set of volunteers. The cost of the procedures are charged to the losing party or to both parties in case of a tie. This system has developed from the experience and has defined a precise manner to help in addressing these conflicts in a quick and standard way, with help from lawyers, while scalable for a growing community.

**Economic compensations system** The economic compensations system has been developed and implemented to compensate imbalances between investment in the commons infrastructure and network usage among the 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<sup>10</sup>. In addition professionals are allowed to charge a reasonable amount for opportunistic connections<sup>11</sup> until their investment is covered.

### 3 Framework for establishing and maintaining cloud-based services in Guifi.net

#### 3.1 Principles

The principles that apply at network infrastructure level, the conception of the infrastructure as a CPR and the coexistence of volunteer and for-profit partic-

<sup>8</sup> In the European Union as well as in most of the Western countries, telecommunications is a public service that must be delivered by the private sector. In this context, the room for manoeuvre in public administrations is limited to very specific actions (self-provisioning, underserved areas, etc.) and under very special conditions (separate account, self-financed, etc.)

<sup>9</sup> <http://social.guifi.net/groups/guifi-legal/reglament-dels-procediments-de-resoluci%C3%B3-de-conflictes>

<sup>10</sup> Type A 10% (to cover administrative costs), Type B 50%, and Type C 100%.

<sup>11</sup> A client node that connects in a DiY manner to a supernode that has been paid by a professional.

ipants, are well suited for the cloud applications, that is to say, the conception of the infrastructure needed to build the cloud (the hardware and the software) as a CPR establishes a framework for the contributions and the collaboration between volunteers and for -profit professionals. Nonetheless, as in the case of the network infrastructure, the implementation of these principles at the cloud level requires effective rules and tools.

### 3.2 Identified tools

**Software tools** In the same way as for the network infrastructure, a set of software is required to ease the tasks of deploying the infrastructure and manage it.

**Software distribution** Cloudy, the CLOMMUNITY software distribution, is a key component to put the cloud infrastructure in place. Figure 1 shows the installation screen. Cloudy installs like a standard Debian distribution and is given in three flavors: As a standalone version to install on real hardware, a container-based one to install on a virtualized operating system, and an operating system image to install on virtual machines. Compared to the Guifi network infrastructure management, Cloudy's role is similar to that of the web portal, and it has been designed with Web-based GUI to ease the deployment and administration of services.

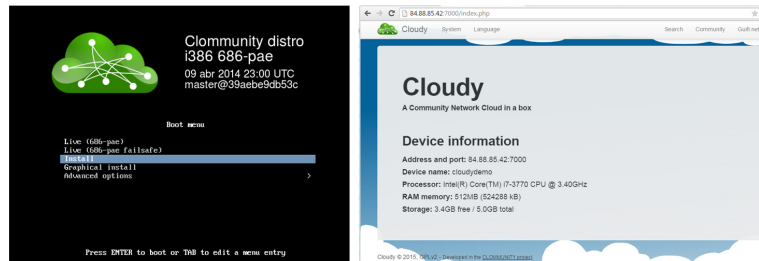


Fig. 1. Cloudy installation and Web GUI.

**guifi.net services** The guifi.net services (proxy system, DNS system and graph system) have been integrated into Cloudy easing the process to set up a *guifi.net* server. Cloudy is expected to become the *official guifi.net distribution*.

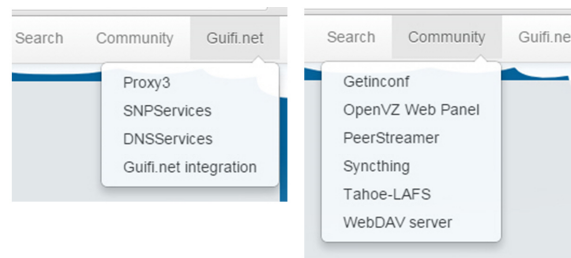
**Distributed announcement and discovery of services** Integrated as part of Cloudy, this service is expected to improve the user experience of the process of finding services available (so far services are listed in a static list at guifi.net website). The discovered services are presented to the user grouped by categories and, in similar fashion as the realtime information about nodes availability, information about the convenience of each of them is presented to the user.

**IaaS** A method to allocate virtual machines is part of Cloudy.

**PaaS** Cloudy uses the guifi.net authentication system.

**SaaS** Cloudy integrates third party cloud applications (peerstreamer, owncloud, etc.) and a system to integrate new ones.

Figure 2 shows Cloudy’s Web-GUI after login. It can be seen that Cloudy contains the three main types of services, i.e. search, community services, and Guifi.net services. The services for community network management are shown: the proxy service, to enable a gateway to the Internet. The SNPServices is a tool used for network monitoring and DNSServices activates a DNS server. Guifi.net integration assists the user to register the Cloudy instance in the Guifi.net database. If clicked on the community services, a list of applications appears. These applications can be activated by the user. Currently, Cloudy provides Getinconf, OpenVZ, Peerstreamer, Syncthing, Tahoe-LAFS, WebDAV. OpenVZ allows Cloudy users to provide infrastructure resources to the cloud. Peerstreamer allows live streaming of events. Syncthing allows to synchronize and share folders among machines and users. Tahoe-LAFS provides a secure and fault-tolerant data storage service.



**Fig. 2.** Cloudy installation and Web GUI.

## Participation tools

**Website** A website devoted to Cloudy<sup>12</sup> and a wiki with technical information<sup>13</sup> have been set up.

**Mailing lists** Two mailing lists to give support to Cloudy users have been set, one is for users<sup>15</sup> and the other for developers<sup>16</sup>.

**Developer community** To contribute to the development of Cloudy or report bugs, users can register at the dev site<sup>17</sup>.

<sup>12</sup> <http://cloudy.community/>

<sup>13</sup> <http://wiki.clommunity-project.eu/>,

<sup>14</sup> [http://en.wiki.guifi.net/wiki/What\\_is\\_Cloudy/](http://en.wiki.guifi.net/wiki/What_is_Cloudy/)

<sup>15</sup> <https://l1istes.guifi.net/sympa/info/cloudy-users>

<sup>16</sup> <https://l1istes.guifi.net/sympa/info/cloudy-dev>

<sup>17</sup> <http://dev.cloudy.community>

**License** We think that a license which harmonises the contributions and usage of the cloud resources can play a key role in the up taking process of the cloud model in a similar way as the influence of the network license has had on the network infrastructure. The license must take into account facts like the relationship between users and service providers, service providers to service providers, etc.

**Reference authority** The fact of having a license is tightly related to the existence of an authority which maintains it and makes sure that it is respected. Furthermore, keeping an organisation running requires resources. A decision on the convenience and the viability of having such organisation must be made. Alternatively existing organisations such as the guifi.net Foundation can be considered to fulfil this role.

**Collaboration agreements** The same way that at the network infrastructure level the commitment with the commons of the operators is expressed through an agreement, a system of collaboration agreements for the cloud shall contribute to enhance confidence among operators offering cloud services. It must be investigated if a graduated commitment system applies to cloud services and/or if it must be service specific.

**Conflicts resolution system** The already existing system for the resolution of conflicts can be applied to cloud matters.

**Economic compensations system** A clear economic compensations system contributes to clarify the terms of participation, and thus, reduce number of disputes. The already existing compensations system may be used as a base, but the metrics and the costs must be adapted to fit to the cloud environment requirements. The impact that the success of cloud services may have at the network infrastructure level must also be investigated, its effect on the economic compensations system of the network, especially in the case of commercial services, and if its current calculation system, which is based on the total internet traffic at the IX, must be changed.

## 4 Assessment of Performance and Experiences

### 4.1 Assessment of usage and performance

In this section we measure the technical usage of the community network cloud in terms of instances deployed and services provided. The values of the metrics are obtained through a publicly available Cloudy instance<sup>18</sup>. The usage and performance are indicted in Table 1). It can be seen that in total 37 Cloudy instances are currently active and 15 are from third-party users. An number of actives services can be seen in all of the offered services.

<sup>18</sup> <http://84.88.85.42>

Case	Metric	Evaluation criterion
Distro	No. of Cloudy instances	37
	No. of third-party contributed hosts	15
Usage	No. of dnsservice	5
	No. of owp	4
	No. of peerstreamer	5
	No. of proxy3	7
	No. of serf	36
	No. of snpservice	5
	No. syncthing	7
	No. of tahoe-lafs	3

**Table 1.** Cases, metrics and evaluation.

## 4.2 Cloud singularities

The following differences compared to the network infrastructure have been identified.

**Building elements** At network level, the building elements are the nodes and the links. For the cloud, the building set is not so well defined because, in addition to the physical level, where the host device, *the server*, is a single element, the cloud stack itself (IaaS, PaaS and SaaS) is very likely to be part of a larger set due to the critical role each of its layers play and the interaction among them.

**Dependency and usage of other resources** The resulting asset at the network level is a primary infrastructure, that is to say, it has no inherent dependencies on other infrastructures. This is not the case for the cloud, which inherently depends on the network for the federation/interconnection of the servers and for putting these resources and the users in contact. The consequences of the deployment of an infrastructure with such dependencies must be studied not only from the additional traffic point of view, but also from a more theoretical prospective to answer questions such as, must the dependant infrastructure contribute to the infrastructure on which it depends? How? Up to which point? Which kind of impacts (traffic overload, etc.) and of which magnitude clouds can have on the supporting infrastructure? etc. without forgetting that contents are what give value to the network

**Type of job positions** At the network level the job positions evolved as follows. At the beginning all the work was done by volunteers. It was the time to start the project, to learn from the experience, to start formalising concepts, etc. When the infrastructure started to be stable and the initial atomisation tools had been put in place, the position of *the installer*, the individual who is paid to make installations, appeared. With the advent of the optical fibre and the increase of Internet connection demand, the position of *the service provider* appeared. At cloud level,

does the role of installer make sense? Do all those offerings for-profit services belong to the same category?

**Infrastructure vs. services division** It seems that the emphasis that is made on the scope of the project at network infrastructure level, "guifi.net takes care of the infrastructure, the content is left up to the users", can also be applied at cloud level, but the criteria to determine what must be considered content and what is considered service must be set.

## 5 Conclusion

Community clouds are motivated by the potential to offer new features which differ from those of current cloud service offers in the Internet. Not only additional value would be brought into community networks, but new services enabled by citizen participation could be developed.

This paper reviewed the mechanism which have lead community networks to become sustainable, and extends these mechanisms to the case of community-driven cloud-based services. Some of the identified components were implemented and are already deployed in Guifi.net. The current status of the deployment shows the technical feasibility and initial take-up of the proposed system by the citizens.

In order to enable a fully fledged ecosystem around community network clouds, next steps should focus on enabling the measurement and accounting of contribution and usage, to fully enable the economic compensation system already functional at the network level. Explorations by SMEs with close-to-market services should be supported in order to understand the viability of different business model options.

## Acknowledgement

This work was supported by the European Framework Programme 7 FIRE Initiative projects CONFINE (FP7- 288535), CLOMMUNITY (FP7-317879), Universitat Politcnica de Catalunya-BarcelonaTECH and by the Spanish government under contract TIN2013-47245-C2-1-R.

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