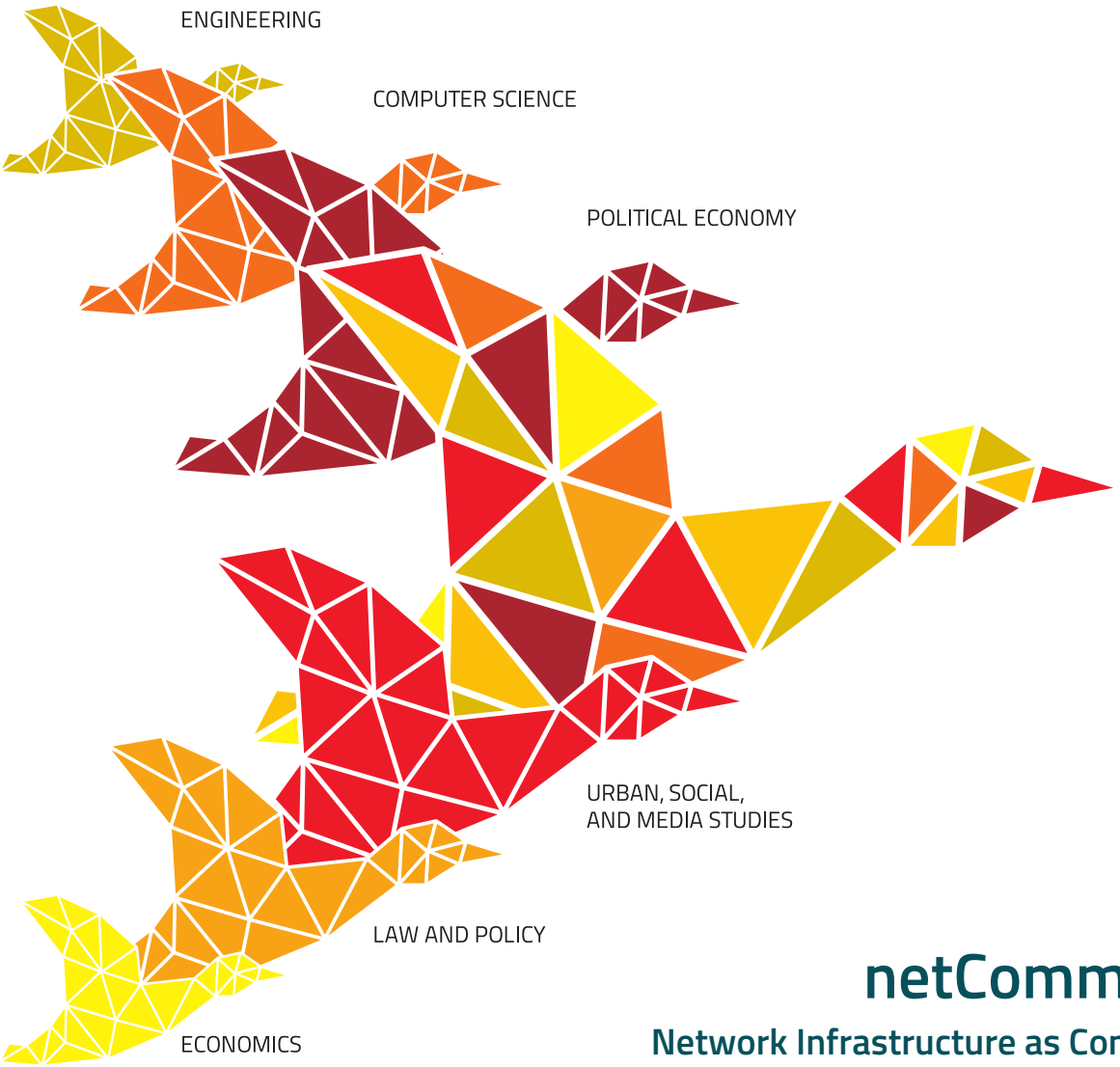

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Network Infrastructure as Commons

Report on the Governance Instruments and their Application to CNs (v2)

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Executive summary

This deliverable is part of Task 1.2: *"Improving governance: impact on Community Networks (CNs)"*. The ultimate expected outcome of the task is the improvement of the governance models of CNs. This is the final deliverable of the task and it builds on the results of the previous documents that describe existing CNs and their organization framework (D1.1 [1], D1.2 [2]), and existing organizational models, and organizational patterns and anti-patterns (D1.3 [3]). The work carried out draws also from the global and sustainability analysis of WP2, the legal analysis in WP4, but most of all on the developed software in WP3, which is used to extend the notion of Information and Communications Technology (ICT) related commons beyond the physical infrastructure of a CN to the services that can be built on top of it.

This deliverable focuses on the application of previous results towards re-engineering: comparisons of internal and external models, patterns, and finally plans, progress and results of interaction with selected CNs in the processes to incorporate such governance instruments within the routine management of CNs. As part of that work we provide an analysis of both the internal and external organizational models of guifi.net, Sarantaporo.gr, TakNet/Net2Home, Zenzeneli, B4RN. We look at a mapping of the relationship to the organizational patterns to these and other CNs. We discuss about metrics for the evaluation and impact assessment of organizational changes, based on the models and patterns we developed, in several CNs, classified into three groups: under consideration (involving FFDN, Rhizomatica, W4C), under implementation (involving Zenzeleni, Net2Home, eXO, ninux), and under validation (several collaborations involving guifi.net: community clouds, municipal ordinance, investment model for fiber deployment). The report presents the case of community clouds in guifi.net, formalized in the last 18 months as a framework for community clouds as open commons, and sustained by the software development in WP3.

The results achieved in influencing CNs are extremely satisfactory. Indeed, not only CNs members and activists welcomed the interaction with netCommons researchers, but it turned out that in many cases they seek for external recognition and also external support and cooperation. Sometimes the impression that they are geek-based, isolated groups is only due to the lack of a proper legal/societal framework that makes it difficult to describe what they are, and also leaves the impression of them being always on the fringe of legality, thus nurturing a *keep a low profile* attitude.

In terms of *contribution to netCommons goals* (see Sec. 7.1 for more details), the work carried out in Task 1.2 contributed to achieve netCommons goals in several ways. In general, helping CNs to address many challenges by providing abstractions, models and practical tools to grow and produce a higher beneficial impact on our society. Based on the portfolio of organizational models developed (T1.1), we have analyzed, provided feedback and supported several CNs in their processes to evolve their internal governance structures towards adaptability, effectiveness, efficiency, and achieve more organizational resilience and sustainable growth (Objective 1.2). In particular, the organizational models of several CNs have been analyzed in detail, presented in summarized form (external and internal models), mapped in relationship to the organizational patters defined in D1.3, and then supported in their processes of organizational development and change towards maturity.

In terms of *Impact of the work* (see Sec. 7.2 for more details), besides contributing to achieve the scientific and societal goals of netCommons, Task 1.2 has and will have a direct impact on CNs as well as on the understanding of networking infrastructure commons and the application to organizational improvement. Referring to the *CAPS* work programme objectives, we T1.2 impact refers to:

a) pioneering the maturing promising models of participatory innovation;

b) defined new concepts and models for the development of digital social platforms for local connectivity;

c) helped to optimize their applicability to societal challenges;

d) provided evidence-based understanding of the techno-social issues related to the domain of connectivity and digital inclusion.

e) supported active citizen participation in decision making, collective governance, new democracy models, self-regulation, new business and economic models.

f) worked with different key stakeholders and contributed to create measurable improvements in the cooperation among them to develop sustainable and collaborative connectivity.

In terms of the impacts defined in netCommons, the definition, development, comparison and improvement of organizational models has delivered the following impacts:

Local Impact 1: (Governance guidelines for CNs), specific impacts: 1) Improve the internal governance of communities synthesizing organizational models, get better decision making processes; 2) Increase their touch (on values, awareness, acting) on the external society, through improvement of external organizational models.

Local Impact 2: (Sustainable growth of CNs), specific impact 1. Help communities to formalize their political and social goals;

Global Impact 1: (Alternative Internets Made Possible) through the adaptability and sustainability brought by organizational development and maturity.

These impacts are not only attested by the interactions and organizational evolution processes involving several CNs involved, but also globally through interaction with other CNs and global actors, such as the Internet Governance Forum (IGF), Institute of Electric and Electronic Engineers (IEEE), Internet Society (ISOC), Association for Progressive Communications (APC), among others.

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List of Acronyms

APC	Association for Progressive Communications
AIT	Asian Institute of Technology
BMC	Business Model Canvas
B4RN	Broadband for the Rural North
BT	British Telecom
CAPS	Collective Awareness Platforms for Sustainability and Social Innovation
CC	Community Cloud
CN	Community Network
CPR	Common-Pool Resource
DEF	Digital Empowerment Foundation
EC	European Commission
FFDN	Fédération French Data Network
GAIA	Global Access to the Internet for All
GSM	Global System for Mobile Communications
IaaS	Infrastructure as a Service
IEEE	Institute of Electric and Electronic Engineers
ICT	Information and Communications Technology
IGF	Internet Governance Forum
IM	Instant Messaging
ISOC	Internet Society
INCA	Independent Networks Co-operative Association
IRTF	Internet Research Task Force
LFFN	Local Full Fibre Networks
NPC	Non-for-profit company
PaaS	Platform as a Service
SaaS	Software as a Service
SME	Small Medium Enterprise
SLO	Service-level Objective
SME	Small and Medium Enterprise
W4C	Wireless For Communities

1 Introduction

The objective of this report is to analyze the impact of organizational changes in the governance of specific community networks (CNs).

This work extends our results on organizational aspects in Deliverables D1.1 [1], D1.2 [2], and D1.3 [3].

From the netCommons proposal, the description of Task 1.2: *Improving governance: maximising the impact on CNs* is as follows:

> "*This task will identify what are the best governance tools (policies, agreements, decision making platforms etc.) for CNs to fine tune their internal organization, improve their resilience, optimize their sustainability, reduce gender divide. This analysis will be included in form of recommendations and best practices to improve the platform in Deliverable 1.2. Through active work within the CNs, meetings and participation to workshops co-organized by T6.1, the personnel involved in T1.2 will work to help selected CNs to incorporate such governance instruments within the routine management of CNs. A monitoring phase for the evaluation of the initial impact of the recommendations will also be carried out and will be reported in Deliverable 1.3* (and D1.4)."

Community networking infrastructures have been developed in many locations and communities to address the essential need of citizens to participate in the digital society and support communication in the artificial digital space as we can do in the natural visual, acoustic space. CNs are described in Deliverable D1.2 [2] as global commons with a central artificial material commons component. These infrastructures enable self-provisioned and self-organized ways to build and ensure social interconnection and access to knowledge, content, and communication. Community networks combine the need to have infrastructures to support local socio-economic interaction, with experiences about the governance and management of common property, according to ideals related to the engagement of citizens, developed along the history of grassroots community organizations. From a commons perspective, diversity makes a difference. Each CN has created diverse local institutions and organizational structures of varied sophistication, adapted to local conditions and needs. Each initiative adapts to its locality, with slightly different points of origin, values, strengths and weaknesses, and diverse levels of development and structuring.

We draw on the analysis and identification of good governance tools regarding the external perception (outside view), and the business model, as well as the internal governance of several CNs described in D1.3[3]: guifi.net and eXO (Spain), Ninux.org (Italy), FDN and Tetaneutral (France) in Europe, Wireless For Communities (W4C) (India) and Rhizomatica (Mexico). We include additional CNs we have been working with: Sarantaporo.gr (Greece), Zenzeleni (South Africa), B4RN (UK), TakNet/Net2Home (Thailand). Both in D1.3 and this report, we have developed models for **outside view** of what CNs do, the external relationships and its **inside view** of how they operate, the internal relationships. For the outside view we were inspired by the social business canvas model [4]. For the inside view we looked at the evolution of the organizational framework from deliverable 1.2 [2]. We also draw on the *synthesis* of a set of common and relevant organizational patterns and anti-patterns in CNs.

Here we focus on the re-engineering aspect: How previously identified governance instruments can be adapted and applied to help these and other CNs evolve their governance and become more resilient, adaptable, sustainable, and scalable. The interaction with several CNs has resulted in direct and indirect exchange of experiences and organizational instruments to handle similar issues with different local nuances. Together with the CNs involved, we have identified several areas for further development (re-engineering). The goal is assisting several CNs, some of them very prominent, which have expressed interest to incorporate governance instruments or

improve existing ones. These developments consist on restructuring the network to incorporate improvements that can affect their outside view or inside view, or organizational reshaping to be implemented as the communities plan and then transform to react to challenges or opportunities, such as scaling up, or consolidation through professionalization.

Re-engineering means working with each CN interested to incorporate such governance tools and promote certain organizational patterns or mitigate certain anti-patterns, always adapted to the characteristics of each. Improvements and restructuring can have different degrees of impact in the outside or inside view of a CN, and different time scales for implementation. The focus of this report is the analysis around the re-engineering processes, with the definition of metrics to monitor the output (application of instruments) in terms of improved resilience, scalability and sustainability.

The research method included participatory action research [5]. The work with communities takes place through remote interactions, meetings co-located to international gatherings, or on-site visits. The discussions were around the planning, co-design, transformation, and result phases of the action research. These interactions were useful to better understand the needs and local characteristics, to obtain feedback about organizational and governance features, and to refine and generalize the models.

The report is organized along different sections that include:

a) *A comparison of external organizational models and CNs* in Chapter 2. We expand the list of CN analysed in D1.3, which brings more diversity, and we also include the additional sections on social & economic costs and benefits.

b) *A comparison of internal organizational models and CNs* in Chapter 3. We expand the list of internal models according to the framework defined in D1.3.

c) *A mapping of organizational patterns and CNs* in Chapter 4. A classification and discussion about how these specific patterns apply to different CNs.

d) *An analysis of organizational change in CNs* in Chapter 5. We present the status of organizational developments in each initiative, classified into three groups: under consideration, under implementation, and under validation.

e) *Community Clouds and guifi.net* in Chapter 6. The most detailed organizational change in collaboration with guifi.net was to define an organizational model for community clouds, based on the experience of the experimental Cloudy deployment in guifi.net.

2 Comparison of external organizational models of CNs

The external organizational model, also referred as the outside view of an organization, shows how a commons is structured to achieve or maximize its social impact in the socio-economic local environment, highlighting the direct and indirect benefits brought by the production and consumption of connectivity (what we typically call business impact) by leveraging the commons, while preserving and nurturing it [3].

For the comparison of the features of external organizational models, we have looked at several CNs, already studied and new ones, and discussed with members or representatives of each of them. We have worked with them to identify and diagnose opportunities for organizational development and refine their and our own models and provide a basis for comparison.

Community networks develop and manage a commons (like traditional communal grasslands or irrigation systems), i.e., the *telecommunications infrastructure*, that produces an extractable resource from this common infrastructure, which is *connectivity* (regional or global). Participants develop and manage the network infrastructure commons to achieve social objectives. However, when considering sustainability (i.e. the ability to be maintained at a certain rate or level, which is related to organisational, governance, and economic aspects), business objectives (i.e. "the rationale of how an organisation creates, delivers and captures value" [6]) have to be oriented to preserve or expand the commons. This may be different depending on the stakeholders: volunteers may be motivated by personal interest or the wish to achieve social impact, professionals by economic return (money) and connectivity users (customers) by low cost (money, in absolute terms or relative to the cost-benefit balance of alternatives). Community networks are not clubs, closed groups, to self-provide their own connectivity, but they are commons infrastructures that are open to anyone in the community. Anyone is welcome to participate to, or benefit from, the commons according to the access and participation rules. Natural commons, including natural materials such as air, water, and a habitable earth, deal with the preservation of a pre-existing resource system. In contrast, human-made commons such as irrigation systems, or computer networks in our case, are open as they are extensible by crowdsourcing. As new people and new locations join the network, the reach of the infrastructure expands, and therefore more new people becomes on reach. If the expansion comes with proportional contributions, not only the reach but also the capacity and resilience of the infrastructure can grow.

As Ostrom [7] found that larger Common-Pool Resources (CPRs) tend to have complex multiple layers of nested enterprises with small local CPRs at their bases, we have found that large CNs can have more than one layer of organization to scale up or accommodate diversity in how each part of a community is organized. They appear as a federation of more homogeneous or strongly coupled CNs. Therefore, although the distinction can be based on many nuances, we distinguish sharply between CNs with a single, or with multiple layers of organization. With a single layer we have AWMN, eXO, Sarantaporo.gr, TakNet/Net2Home, Zenzeleni, B4RN. With more than one layer we have FFDN, Freifunk, guifi.net, ninux, Rhizomatica, W4C. Fédération French Data Network (FFDN) is already defined as a "federation", and W4C acts like that, typically around community centers (telecenters) with different levels of autonomy. Freifunk has a light "central" structure with many local groups that share values but are autonomous. Similar but more coordinated is the case of ninux, with local groups and local networking islands of connectivity. guifi.net has one layer of global "umbrella" organization, coordinated by the guifi.net Foundation, and many local groups and local networks. All of them connected across socially and organizationally, under common governance principles, but all local networks can differ in specific technological choices, local "business" and governance models. However, each of these local networks may or may not be interconnected with each other as a seamless computer network. Therefore when we discuss about external organizational models we need to focus on homogeneous groups: either a single layer CN or one local CPR that is part of a larger and diverse CN.

As a summary view of external organizational models, as we did in D1.3, we look at these from the perspective of a business model as it clearly articulates *"The rationale of how an organization creates, delivers and captures value"*. This allows the understanding of how CNs organize to generate and distribute social value and economic value in a sustainable, adaptable, resilient, and participatory way.

We look at the generation of social value (from the production of connectivity) and financial value (from the investment and expenditure to achieve financial sustainability and generate a surplus that can be reinvested locally). For a commons, "business" can be understood as the activity that results in the production of connectivity obtained from a commons network infrastructure to its participants, and alternatively it can be called "sustainability model". This activity in a CN is cost oriented (in the sense of ensuring that costs are covered and margins can be reinvested) and not profit oriented (in the sense of extracting benefit from the community to be given to external investors).

The business or sustainability model, a "canvas" (Business Model Canvas (BMC)), is represented in one diagram that shows how everyone relates directly, indirectly or even potentially (anyone that can relate to) to a CN, how that infrastructure generates impact (social value) from the consumption of the extractable resource (connectivity), and how everyone contributes to develop and maintain the core resource (the network infrastructure).

The BMC is a dynamic tool. It can depict the state of the organisation in 'current' time, but it is also helpful to represent the best understanding of the business model at each time. As an organisational 'snapshot' it is regularly revisited (more often at the beginning, more rarely in its maturity) in order to align with the (internal and external) feedback on its validity and efficiency. As a summarized representation, everyone and everything related, real and potential, should appear in detailed or summarized form. It can help to understand why and how a particular commons relates to and can serve its environment. It can help redesign, innovate or optimize its operation and interaction with its environment, to maximize its positive impact. In contrast, the internal organizational model, analysed in Chapter 3, describes the forms of participation in the decision-making concerning the CN's operation.

Therefore the external view shows how a commons is structured to achieve or maximize its social impact in the socio-economic local environment and outlines the direct and indirect benefits brought by the production and consumption of connectivity (what typically is called business impact) leveraged by the commons, while preserving and nurturing it.

Typically the time-line for the development of new CNs goes from an analysis of the needs (requirements and planning), to the organizational design, and its implementation as operational structures to ensure the expected impacts, while preserving the commons for the future, as it expands by crowdsourcing and crowdfunding. Existing communities need to adapt as they learn from their experience, or as they adapt to environmental changes or challenges.

For that reason, the canvas model takes into account the dimensions of a) usage, commerce (exchanges), compensations which can be accounted in economic terms, b) the social impact, which can be accounted in quantitative or qualitative metrics, and c) the nurturing and preservation of the common infrastructure. Furthermore the canvas can also show to what extent the CN and each of the key roles can be feasible, fruitful and sustainable.

The main sections of a canvas model, illustrated in Fig. 2.1, are the following:

Key partnerships: The network of surrounding organizations (suppliers, authorities, partners, supporters) that enable and make the commons work.

Key activities: The most important things that need to be done to make the commons work and deliver value.

Key resources: The assets, tangible and intangible, that make your business model work. What drives your economic or social model, and what drives your impacts: The infrastructure commons is a resource aggregate (subject to contribution and consumption).

Value propositions: The products and services that create value for specific participant segments – what keeps participants returning to your "enterprise".

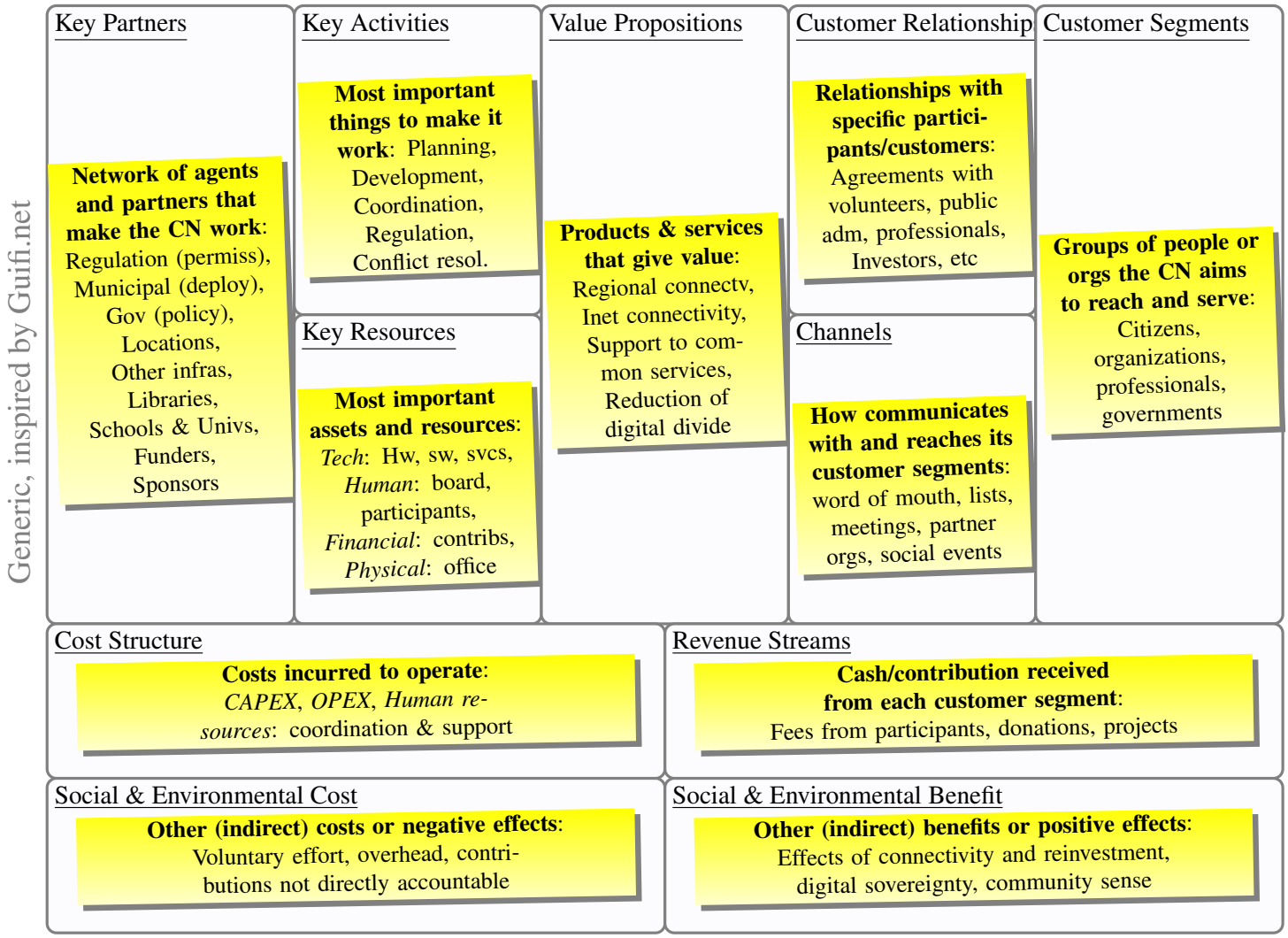

Figure 2.1: A template for the canvas of the outside view of a community network, inspired in case of guifi.net

Customer/participants relationships: The types of relationships a commons establishes with specific customer/participant segments.

Channels: How an CN communicates with and reaches its customer/participant segments to deliver its value proposition.

Customer segments: The different groups of people or organizations an enterprise aims to reach and serve (and become participants, with full rights, not mere consumers).

Cost structure: The cost of the services, the cost in delivering an impact, the cost in contributing to the infrastructure commons, and its compensation to reach a balance.

Revenue streams: What enables to operate (exchanges, consumption, services) and generate the impact.

Social and environmental cost: (optional) negative externalities not included in the cost structure.

Social and environmental benefits: (optional) positive externalities not included in the revenue streams.

2.1 The case of guifi.net

The diagram in Fig. 2.1 shows a brief description of what guifi.net implements in each BMC section (bold) and generic information about what the section can actually contain (plain text). This diagram is taken and generalized from the guifi.net organizational model. The case of guifi.net as a federation, and the specific case of the eXO, one of the local community networks, were described in detail in D1.2 [2] and summarized as a BMC in D1.3 [3], and are thus not reported here in detail.

2.2 The case of Sarantaporo.gr

Sarantaporo.gr is a CN, which connects 11 villages through a common telecommunication infrastructure and provides access to its network services. It is located in the rural area of Elassona, in the north-western part of Greece. The poor access to basic telecommunication services due to non-existing network infrastructure stood as the main motivation for the development of this CN. Due to the geographic location and small population of the villages, network operators had not invested in the area until quite recently. Hence, the locals did not have access to the Internet and subsequent services that are dependent on ICT. The core team of Sarantaporo.gr launched its activities in 2010. A group of people got together on a voluntary basis and started creating a wireless CN that provides access to broadband services for local residents, local institutions, groups and visitors of the area. Network equipment was first installed in the Sarantaporo village; gradually, nearby villages followed with the help and cooperation of active local residents and communities.

Sarantaporo.gr was described in detail in D1.2 and here (not included in D1.3) we present the external business model represented in Fig. 2.2.

There are challenges relating to reaching its beneficiaries (“customers”) because customers here are segment specific. For example, there are currently more than 100 unconnected (not even land line) animal farms in a plain in the vicinity of Sarantaporo; only three of them have been connected to Sarantaporo.gr CN by now. More have applied to be connected, but the needed operational capacity exceeds the resources of the Sarantaporo.gr organization. External collaborations and training are considered a way to tackle this challenge.

Sustainability-wise the organization is currently implementing a new approach to engage locals in supporting the CN. It is based in the concept of “node adoption”, where each node owner “adopts” a piece of equipment by contributing a yearly subscription for its maintenance and the maintenance of the CN overall, instead of relying on the node owner himself to maintain the equipment. This model has worked well so far, but additional financial resources are still needed to achieve sustainability. In large part these are are coming from grants and funding programs, which cannot be assumed to last forever.

Important key partnerships that remain to be established are with local farmers’ associations and the church. The later can offer many prominent locations to install the equipment. The former are an important player concerning local economy.

Sarantaporo.gr

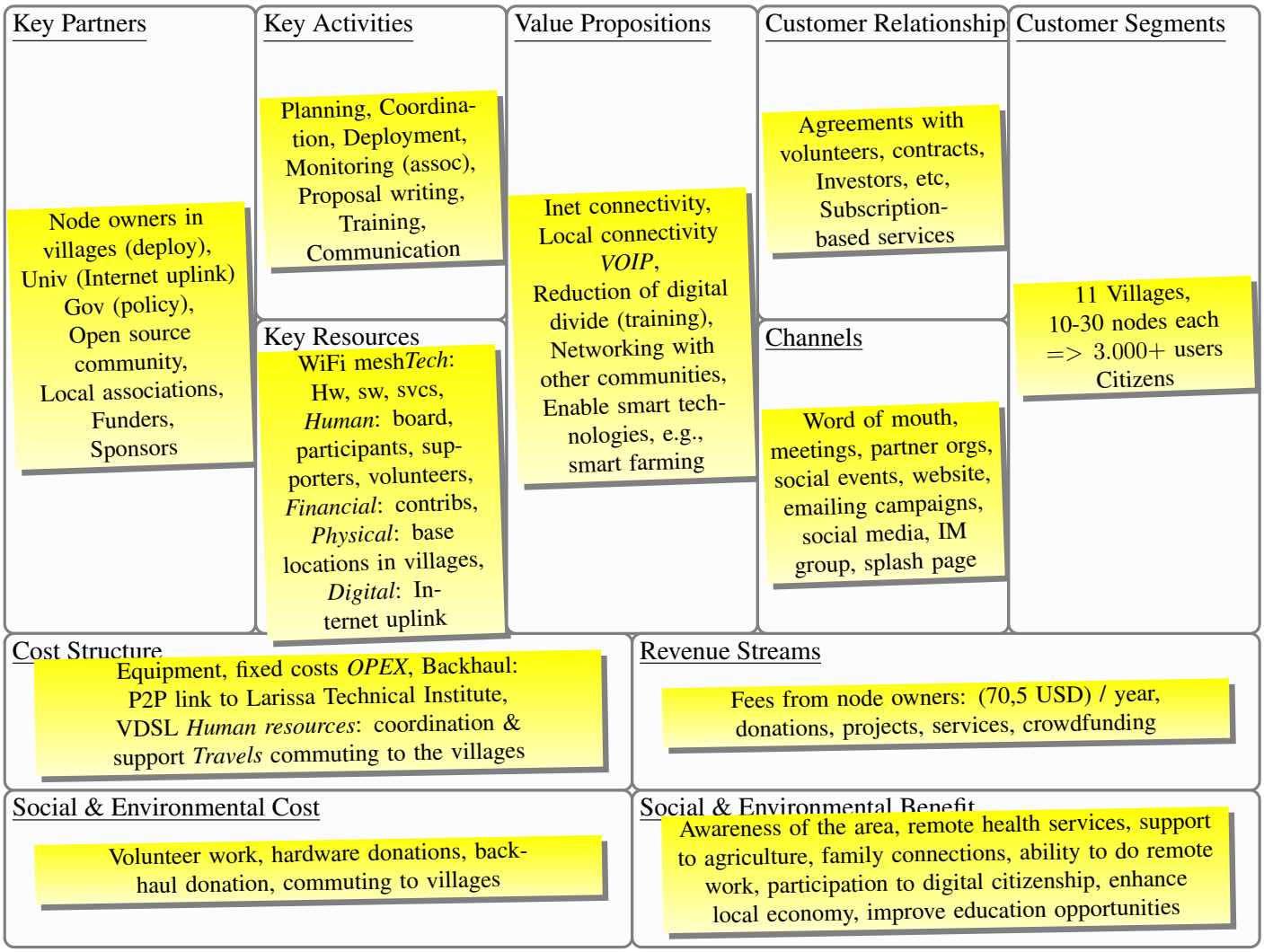

Figure 2.2: The canvas of the outside view of the Sarantaporo.gr network in north Greece

2.3 The case of Taknet and Net2Home

TakNet appears in these reports for the first time. This is the result of a long lasting collaboration with the Asian Institute of Technology (AIT) and the University of Cambridge in the context of the Global Access to the Internet for All (GAIA) Internet Research Task Force (IRTF) working group. TakNet [8] is a group of community networks deployed in different villages in the north of Thailand since 2013 supported by the Internet education and research laboratory (intERLab) of AIT. The networks have gone through two main phases of deployment with progressively more evolved organizational models. In the first model, TakNet was mostly maintained by the trained local engineers and the staff of intERLab, AIT which is based solely on voluntarism. The second model, called Net2Home and currently under development, follows a more structured model intended to scale up to many more communities and be self-sustaining. Net2Home is managed by a social enterprise. The model, summarized by Fig. 2.3, represents the current model (Net2Home), being implemented in the majority of villages, and under a phase of refinement. In netCommons we decided to work with this community given the unique characteristics of a CN in a remote rural area, in a different culture and representative of the global south, involved in an organizational transition, and interested to work with us. In the transition from TakNet to Net2Home we provide assistance in the development of this model to improve self-sustainability. More rapid deployments, combined with more presence means that Net2Home becomes more visible and could be perceived not just as a way to promote access to connectivity in remote areas, but also it can be perceived as a competitor by commercial ISPs and telecom companies. This expansion implies less or no dependence from public sponsors, equivalent to a subsidy, and an evolution towards a self-sustaining model that is more scalable. This results in planning for higher backhaul costs than the current situation where the network is partially sponsored by THNIC foundation[1] and the academic and educational networks.

The TakNet model was very dependent to AIT's intERLab and voluntary contributions in all aspects, as the local communities do not have the economic, organizational, technical capacities to develop and operate their network by themselves. That had big effect in the sustainability of the network. In fact, an illustrative example of how the network could create new problems. Electricity below certain threshold of consumption is free in these communities, but in some cases, the introduction of always-on mesh routers with a WiFi access point has increased the electricity consumption beyond that threshold which implies paying for the whole consumption, a big shock and an economic problem for the individuals affected.

The Net2Home model has lower reliance on AIT and subsidies, more established procedures, and therefore more local control and local understanding about all aspects of the network. Communities have a more active role, and a higher contribution in the operation and the sustainability. One tangible effect of this, already visible in the initial months, has been an increasing rate of deployment of new communities, as the level of external funding required by each community is lower, and the effort on the AIT side is reduced.

In the first TakNet model, the network was mostly maintained based on voluntarism where the local engineers cooperated with intERLab staff to do some basic troubleshooting and collect the fees from each participant. The fees that each participant needed to pay was just a shared cost of Internet subscription fees and some electricity charges, which cost about 80 THB (2.45 USD). To improve the self-sustainability, in the transition from TakNet to the current Net2Home model, the fees for each participants are increased to 250 THB (7.5 USD), thus covering the cost of maintenance and some local services (e.g., VoIP, Video on Demand, chat application).

[1] http://www.thnic.or.th

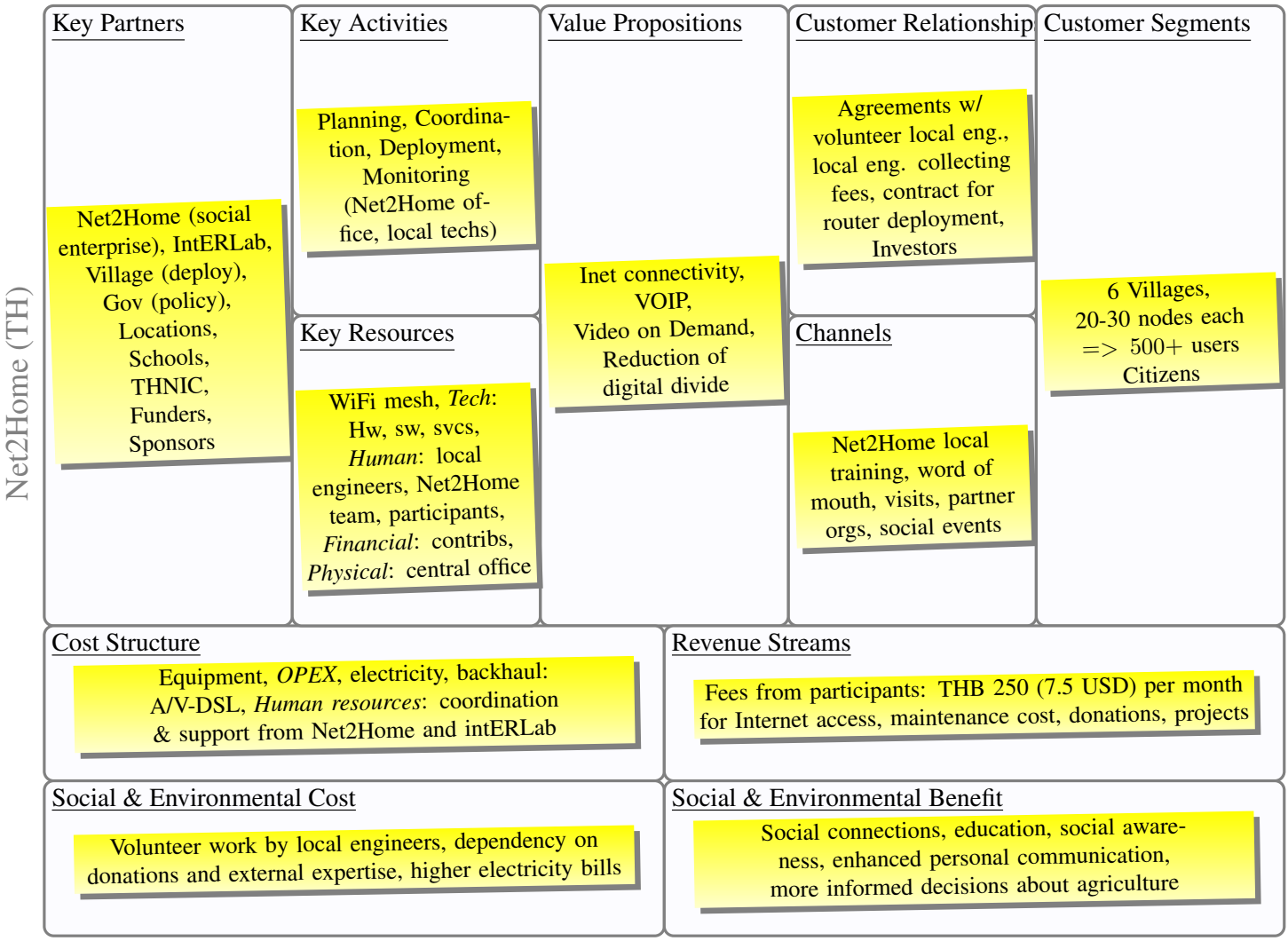

Figure 2.3: The canvas of the outside view of the Net2Home network in Thailand

2.4 The case of Zenzeleni

Albeit mentioned in [3], Zenzeleni is described in this report for the first time. Similar to Net2Home, it represents the most organized CN in Africa, and it is currently undergoing a reorganization to structure, formalize, and scale up its organization. Zenzeleni has a few particular traits that make it special given that it has been developed in an extremely underserved area, it is organized around tribal authorities, it depends on governmental subsidies, the area has no electricity and only spotty access to very expensive cellular access. Furthermore, they expressed interest to work with us, what is very helpful to fine tune and widen the applicability of our models, while helping a CN to guide and implement organizational change towards maturity. This comes as a result of a long lasting collaboration with the University of the Western Cape (UWC) in South Africa, that started in 2012 in the framework of the CONFINE FIRE project coordinated by UPC. It has developed in the Eastern Cape Province, where most of the 3,500 residents live on less than $2 per day. In spite of this, residents spend an average of 22 percent of their income on connectivity and communications [9].

The community network is under the control a committee of the tribal authority, and a cooperative organization, Zenzeleni Networks Mankosi, was established to operate the network. Zenzeleni is a solar-powered, community-owned, WiFi mesh telecommunication network, which provides affordable communications to remote rural areas in South Africa. Zenzeleni, which means “do it ourselves” in isiXhosa, creates solutions for

the unconnected to connect themselves.

The mesh network of solar-powered routers connected to analog phones provide voice service to the community, using Voice over IP (VoIP) technology. There is also a gateway to the Internet, but users rely on basic phones, not smartphones, so the network is used mainly for voice calls. The model allows users to make free internal voice calls, and at half of the normal price for fixed and mobile, national calls, which significantly reduces the cost of 'breakout' mobile calls and data. The solar panels powering the routers allow the communities to charge mobile devices and provide LED lighting for those housing units that host the nodes.

The BMC of Zenzeleni is presented in Fig. 2.4. The social and environmental benefits are extensive:

- Creation of new rural businesses and new rural income streams.
- Provision of, and access to, affordable telecommunications.
- Facilitating community development through the vehicle of collective (community) ownership.
- Maximizing the retention and circulation of capital within rural micro-economies.
- Creating local, critical and scarce higher value added services.
- Retaining the most skilled youth and decreasing the number of forced migration split house holds.
- Enhanced savings for impoverished households.
- Enabling the development of other existing and new rural businesses.
- Increased access of rural households, hospitals and schools to the benefits of connectivity and the digital knowledge economy.

Local anchor tenants, such as business customers, schools, and hospitals, pay the community network for additional network services. This increases the sustainability of the network and helps reduce the economic contribution of the local population. Zenzeleni Networks Mankosi is in the process of expanding to other communities in the region, replicating this model in the new communities. This will have an effect on the costs and the internal organizational model described in Chapter 3. A typical cost and revenue model, still under design, is that a local economic operator invests 2,000 Rand (equivalent to 133 €) to get 10,000 air time vouchers (they pay 20%) that are 15 times cheaper to use than commercial prices, and invests 4,000 Rand for a new hotspot, usually supported by the needs of local anchor tenants.

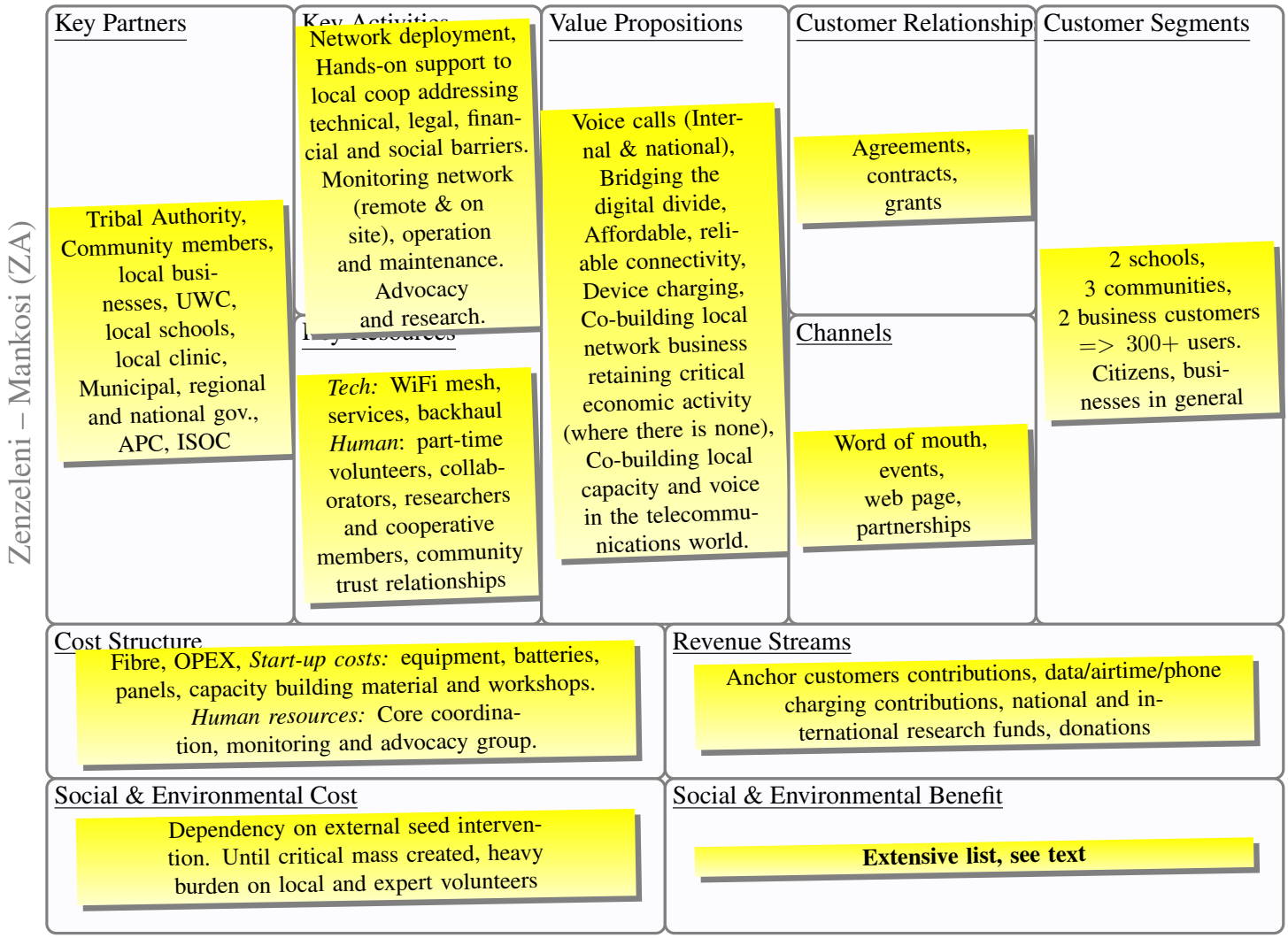

Figure 2.4: The canvas of the outside view of the Zenzeleni.net network in Mankosi

2.5 The case of B4RN

Broadband for the Rural North (B4RN) was described already in D1.2 as part of the UK Independent Networks Co-operative Association (INCA) enterprise. Here (not included in D1.3) we present their external business model represented in Fig. 2.5.

There are many points that differentiate B4RN from most of the other CNs, as usual rooted in the local socio-economic situation. The main points that characterize B4RN model are:

1. Being integrated in a wealthy, well developed country with a clear attitude toward liberal enterprise;
2. The focus on rural areas where inhabitants are clearly underserved, but have a community spirit and have the tools and experience to work in many fields related to communication infrastructures, from building and digging to lay cables to ICT skills;
3. The deployment of fibre to achieve maximal speed and reliability as represented in Fig. 2.6;
4. Coverage of all houses in a territorial division (parishes, villages);
5. A social enterprise that coordinates and supports the technical work, while local volunteers coordinate the social work to plan and collect support, investment, get rights to pass through properties, and provide the effort to dig the land.

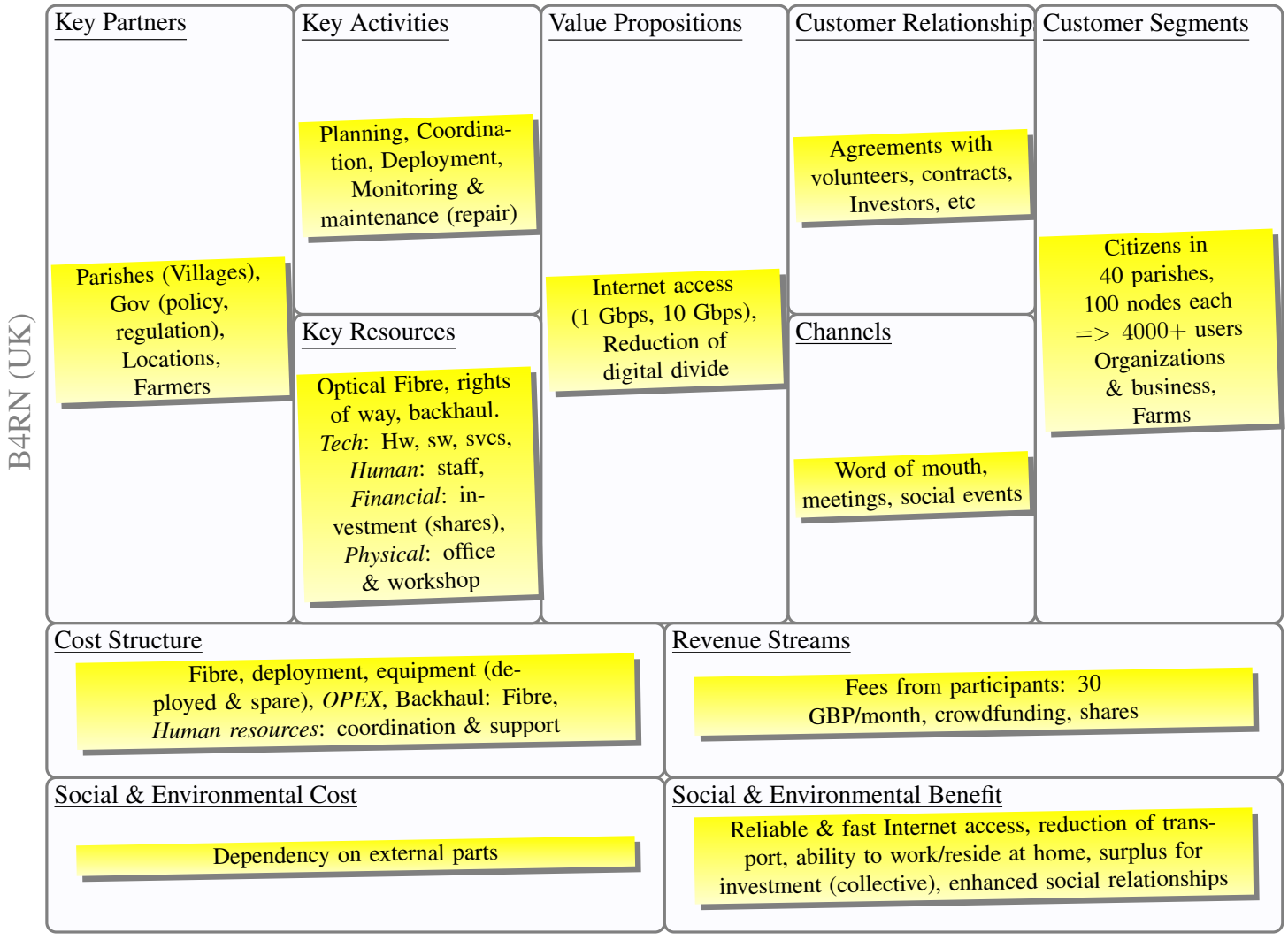

Figure 2.5: The canvas of the outside view of the B4RN network in Lancashire

Figure 2.6: One of the B4RN rural deployments at Gigabit speed

The model combines several organizational patterns, as deployment combine volunteers with help from professionals, the investment is supported by community shares and loans, and the retribution of community effort is done in terms of community shares.

The model has proven very successful in the area and across the UK, with many initiatives following the example of B4RN, such as: Yealand, Silverdale & Storth, Rural Nottinghamshire, Bentham Hyperfast, Killington, Firbank, Howgill, Marthwaite, Cautley, and Sedbergh Town, East Anglia, Burton, Capenhurst, Ledsham, Ness, Puddington, Shotwick, Two Mills and Woodbank, Caton-with-Littledale, South Westmorland, Casterton[2].

2.6 Comparison and discussion

CNs differ in many aspects but all share the value proposition of reduction of the digital divide in their communities, under a very cost-effective model with the goal of investment cost-recovery and non-exploitation use (not extractive model). This is achieved with different services, usually comprising at least voice calls and Internet access. In one interesting case, given the lack of basic infrastructure, the solar-powered communication network also supports electricity and lighting for node hosts, a very beneficial side effect that becomes an incentive to active participation in the CN.

In all cases communities have strong bounds with their local environment. They need and count on the support of a range of local key partners, they perform similar key activities and require key resources, with more or less external support. The channels of communication with their participants (typically called customers) are similar in all cases, and the customer relationships are more or less formalized depending on the maturity and scale of the models. The customer segments define the scope and scale of each CN.

The sustainability models relate to the balance between costs and revenues, either direct or indirect. Among the direct costs there are economic or equivalent to cover the cost of the infrastructure, its operation and maintenance. Among the indirect costs, social and environmental costs, which are required contributions or negative effects, we typically find the need for voluntary work, external required contributions (donations) such as hardware or backhaul, even higher energy costs or travel costs in one case. The typical source of direct contributions (revenue streams) are usage fees, but in some cases these cannot cover the costs and therefore additional contributions have to come from donations or other external sources. We find a wide range of indirect benefits, typically positive social impact in the target communities, that differ in each locality. These positive impacts on the communities are important to determine, understand and maximize, even though they may be hard to quantify.

The features of an external organizational model need to be matched and supported by an internal organizational model, in terms of governance instruments, that is the topic of the next chapter.

[2]The web sites of all these initiatives are: http://www.b4ys.org.uk/, http://f4rn.org.uk, http://www.b4rncasterton.co.uk/, http://benthamhyperfast.weebly.com/, https://www.b4sa.org.uk/, http://b4rn-eastanglia.org.uk/, https://cheshirehyperfast.org.uk/, http://b4rn.catonvillage.org.uk/, http://www.b4sw.uk/.

3 Comparison of internal organizational models in CNs

In contrast to outside views of the external organizational model, which show how a CN interacts with its environment as, metaphorically, a living organism in its ecological niche, an inside view provides the anatomy, the structure of body parts, and the physiology, the functions and relationships of these body parts, of a CN. Therefore the internal organizational model represents the architecture of the governance instruments involving the participants of a CN that makes its external organizational model work. In can be summarized into five groups, represented by five layers as shown in Fig. 3.1 from top to bottom:

1. Good practices,
2. Procedures and internal regulations,
3. Agreements,
4. Ground rules,
5. Local socio-legal framework/environment.

Each layer is composed by several related elements represented as boxes. Each layer is enabled by the organizational instruments in layers below. However, the vertical interactions across individual blocks are not mandatory and they may never happen (e.g., 'conflicts' and 'interventions' are not particularly related to 'economic activity' just below), so, for this reason the horizontal blocks are separated from the vertical ones and they should not be conceived as a hierarchically building an architecture.

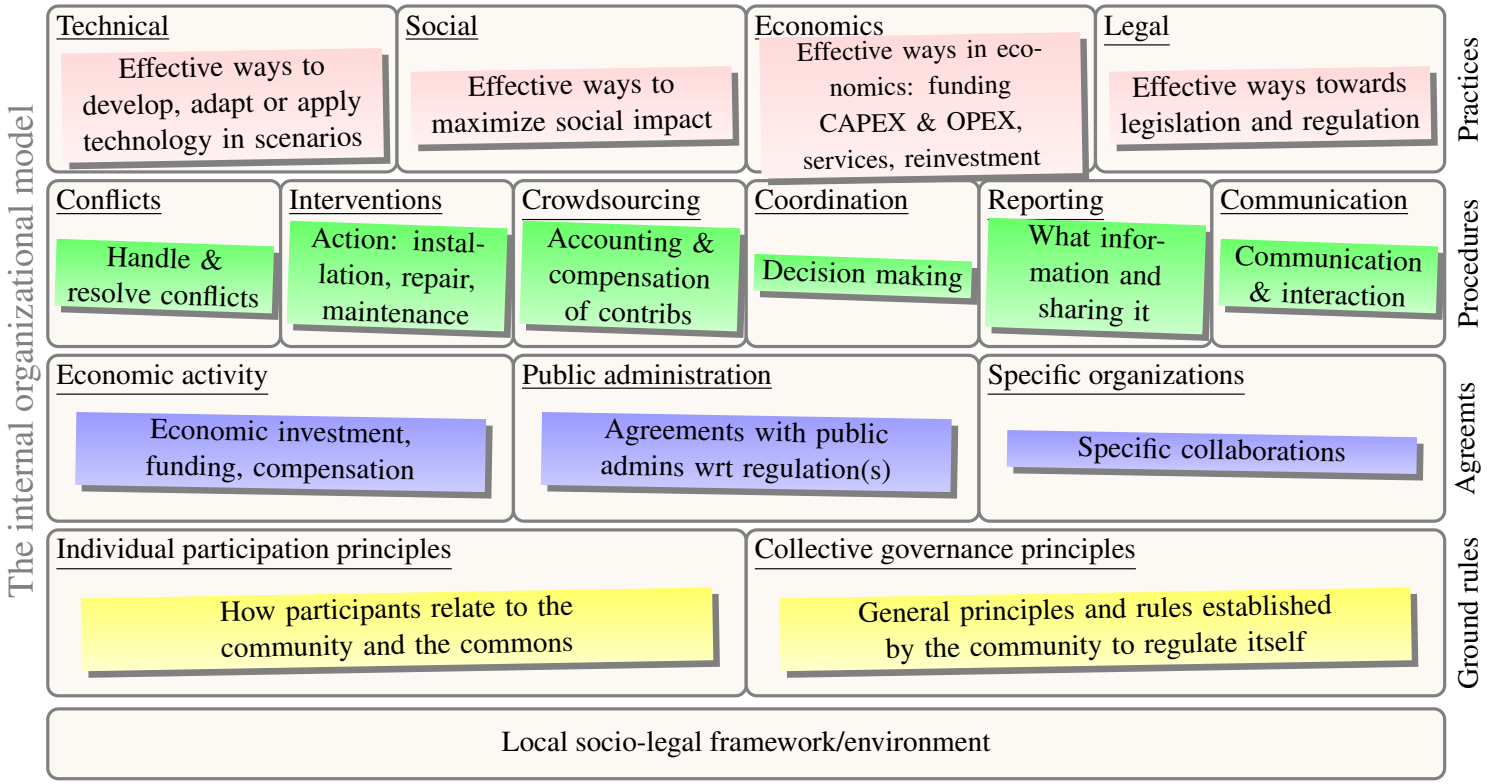

Figure 3.1: The general principles of an internal view

Community Networks exist in a given **local socio-legal environment**, defined by a large set of practices and

rules that apply in that given locality, that can facilitate or restrict the aim of the specific CN. Local choices will be required to build over that environment. The most relevant legal aspects in our case are the regulations and legislation regarding network infrastructures, spectrum, telecom operators, telecom services, legal entities. The most relevant social aspects relate to local social values and typical local structures (typical governance models locally) and forms of social organization (such as existing organizations that support a CN or just customary ways to organize community initiatives, or even power relationships), decision making (typical or established forms to reach agreements), contribution (either be voluntary work, economic, material, professional, corporate social responsibility), political values of the participants. These legal and social aspects define the organizational environment and condition the choices. Whatever done in a given locality has to be shaped by these applicable environmental conditions.

A CN has to define its **ground rules**. Either formal or informal, there are two elements that define the commitments, rights and obligations, and therefore the limits, that shape up participation in the community: these are typically called the *individual participation principles* or participation license, and the *collective governance principles*, typically expressed by the by-laws of the community, that define the general principles and rules established by the community to regulate itself, governing its internal affairs. This can be more or less unstructured depending on the needs and characteristics of the participants and the environment.

However there may be a set of additional internal **agreements**, typically required for the participation of and contribution from certain types of participants like schools, universities, companies, public administrations that regulate access to the public space, or professionals that perform professional economic activities.

The set of ground rules and agreements define a framework where specific **procedures** and internal regulations can be established. Again these can be more or less formal or rigid as needed. We have identified six main categories: procedures for *Communication and interaction*, *Reporting* procedures about information sharing, *Coordination* procedures for decision making, *Crowdsourcing* procedures for accounting and compensation of contributions in terms of human, material or economic resources, procedures for actions or *interventions*, such as installations, repairs, maintenance, and *Conflict resolution* procedures to handle and resolve conflicts, including the outcomes (eventual sanctions).

On top of the procedures and regulations we find the **practices**, the daily life of the organization, that combine and implement the different procedures and regulations, according to the conditions defined by the agreements, ground rules and the socio-legal environment. From that practice we can identify *good practices* (legal, economics, social, technical) that represent learning outcomes of an organization, and therefore should be encouraged to be repeated given the good experience. Obviously good practices define, by exclusion, “bad practices” that are worth to avoid repeating. These good practices can be very specific, dependent on specific details to the internal or external organizational models (local ways), or can be generalizable or adaptable to other environments (generic or adaptable patterns).

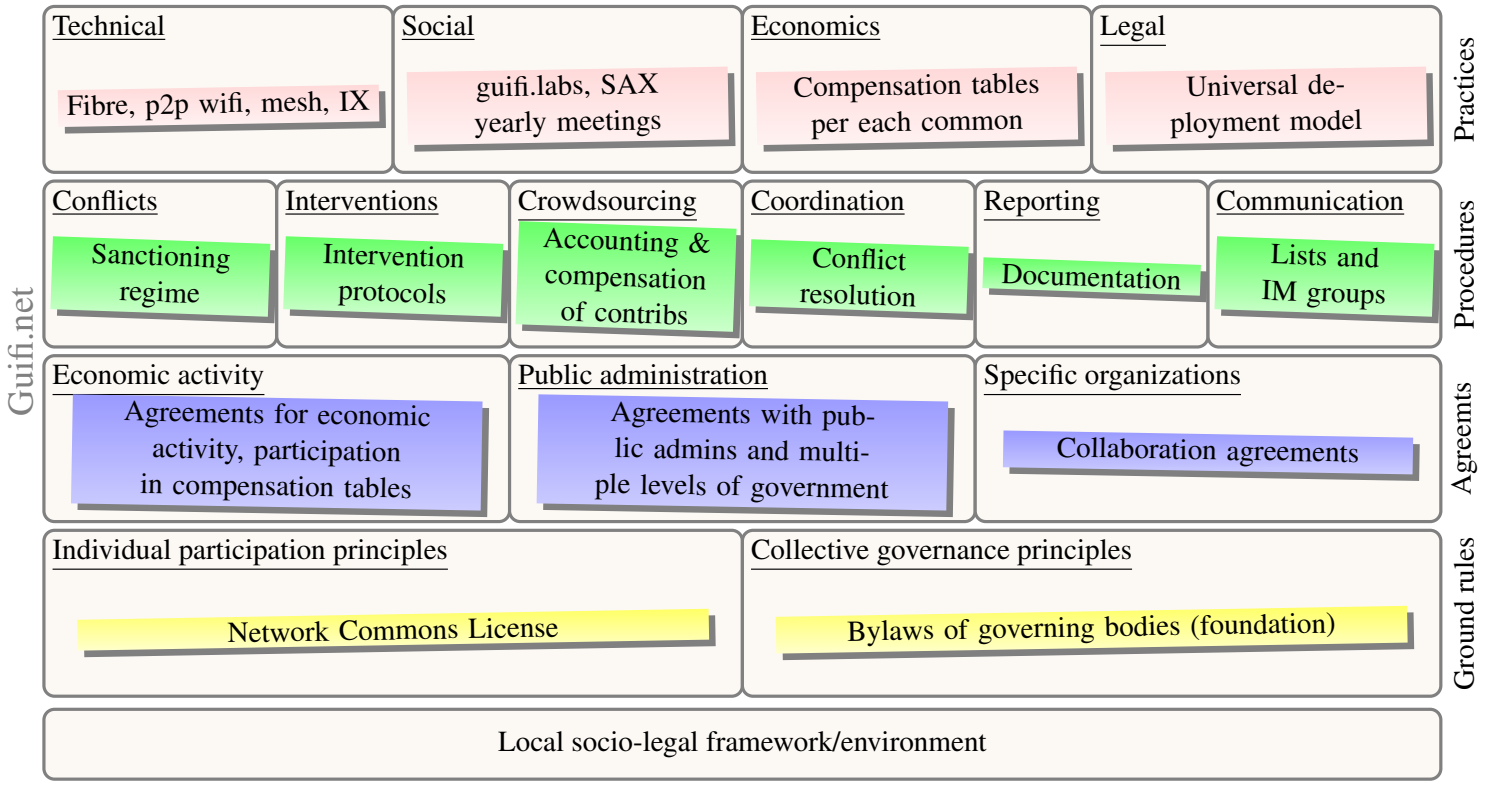

Figure 3.2: The outline of the guifi.net (Foundation) internal view

3.1 The case of guifi.net

The case of guifi.net has served as inspiration to develop the typology of principles for the internal organization to be used to analyze the other cases. In this case, we can distinguish the case of the federation, from the viewpoint of the guifi.net foundation, depicted in Fig. 3.2, and the case of each of the local communities, as is with the case of one of them (eXO) in Fig. 3.3. The diagrams of guifi.net foundation and eXO are obviously very similar, as eXO like any other group inside guifi.net abides to the general principles; however, there are also differences that reflect the different local environment as well as the different perspective of a federation from the one of a local CN.

While guifi.net as a whole is the umbrella for diverse local initiatives, the eXO association is a group with more defined rules in the common framework. Even the name (eXO) is relevant (expansion of the open network) as its goal is to expand the free, open and neutral guifi.net network in a specific area (Barcelona metropolitan area). To achieve this goal additional agreements are necessary, such as the payment of economic contributions and the coordination of voluntary work to help newcomers in planning their nodes, plan the metropolitan network, perform training, organize community events, work with neighbourhoods, social groups and local public or private organizations, deal with local issues like network infrastructure in buildings with many apartments. Both organizations complement each other. For instance eXO buys (shares the cost, according to the economic compensation mechanism) Internet backhaul capacity from the guifi.net Foundation to provide symmetric Internet connectivity to their members. Another example is that eXO organized the guifi.net general assembly (SAX) in Barcelona.

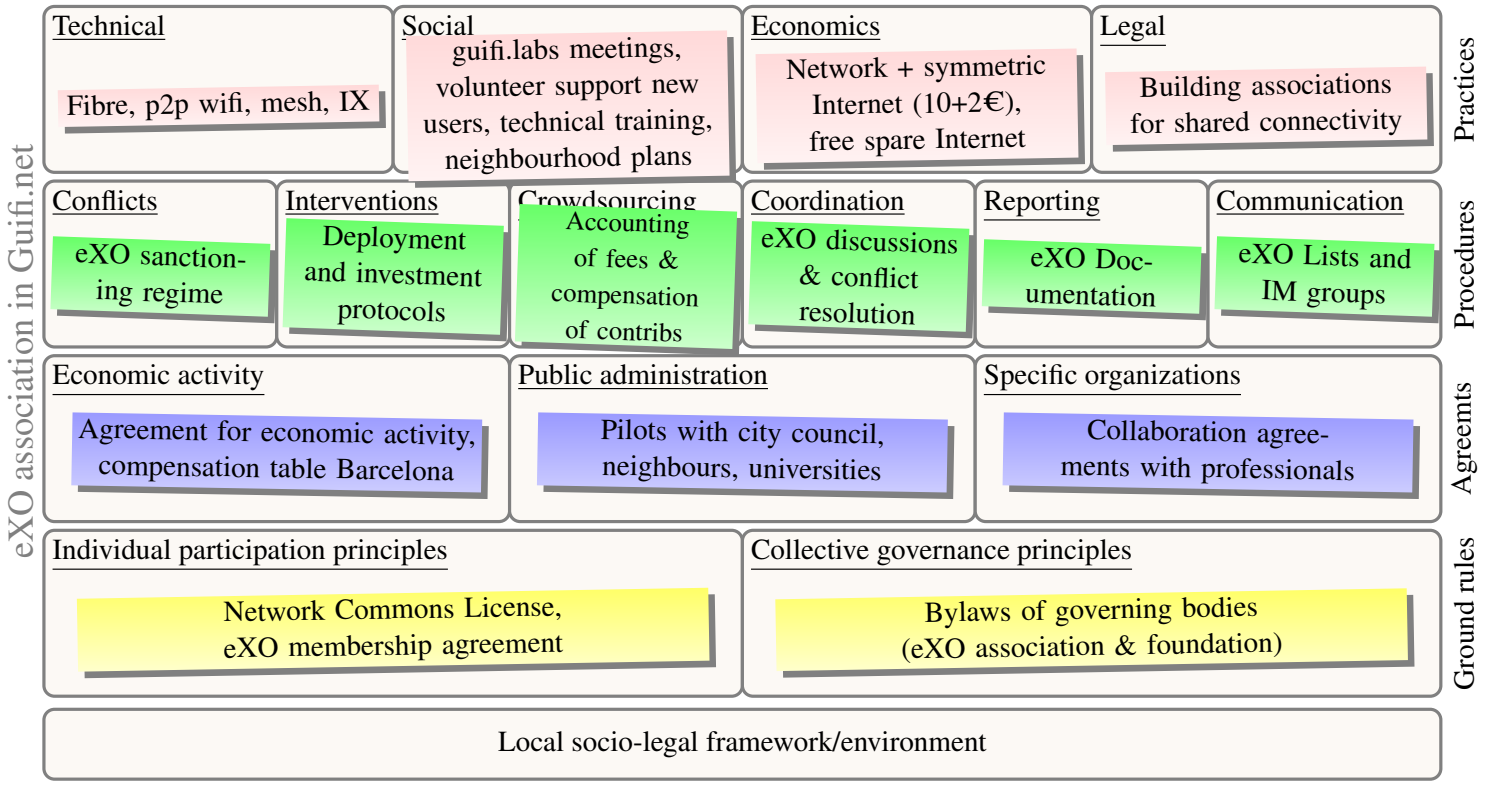

Figure 3.3: The outline of the eXO association internal view

3.2 The case of Sarantaporo.gr

The internal organization of Sarantaporo.gr is presented in Fig. 3.4.

In most part the agreements between Sarantaporo.gr CN and the locals are oral. Trust among locals and personal relations play an important role in setting these agreements. Yet, it is considered necessary to proceed with establishing a formal agreement to avoid misunderstandings and conflicts. The biggest challenge until now has been to describe the "node adoption" (hosting) concept in legally sound terms as the applicable legislation lacks explicit support for community property.

Issues of communication have always been a challenge with Sarantaporo.gr CN in maintaining and expanding relations with locals, mainly due to the distance of the area from the organization's base. Lately, though, the use of a dedicated Instant Messaging (IM) application (Telegram) for communicating with the more engaged and active participants is proving a quite efficient tool. It is supporting the day-to-day communication needs and also serves as a "support hot line", through which locals receive training, guidance and troubleshooting.

These more active participants are considered "local champions" in what regards the operation, maintenance and expansion of the CN. These are people to which others go to when they need support of a technical nature or when considering adopting a new node. Occasionally some training events take place, through which they share their knowledge and discuss various considerations. These events are still mostly organized by Sarantaporo.gr, but self-organizing is greatly encouraged.

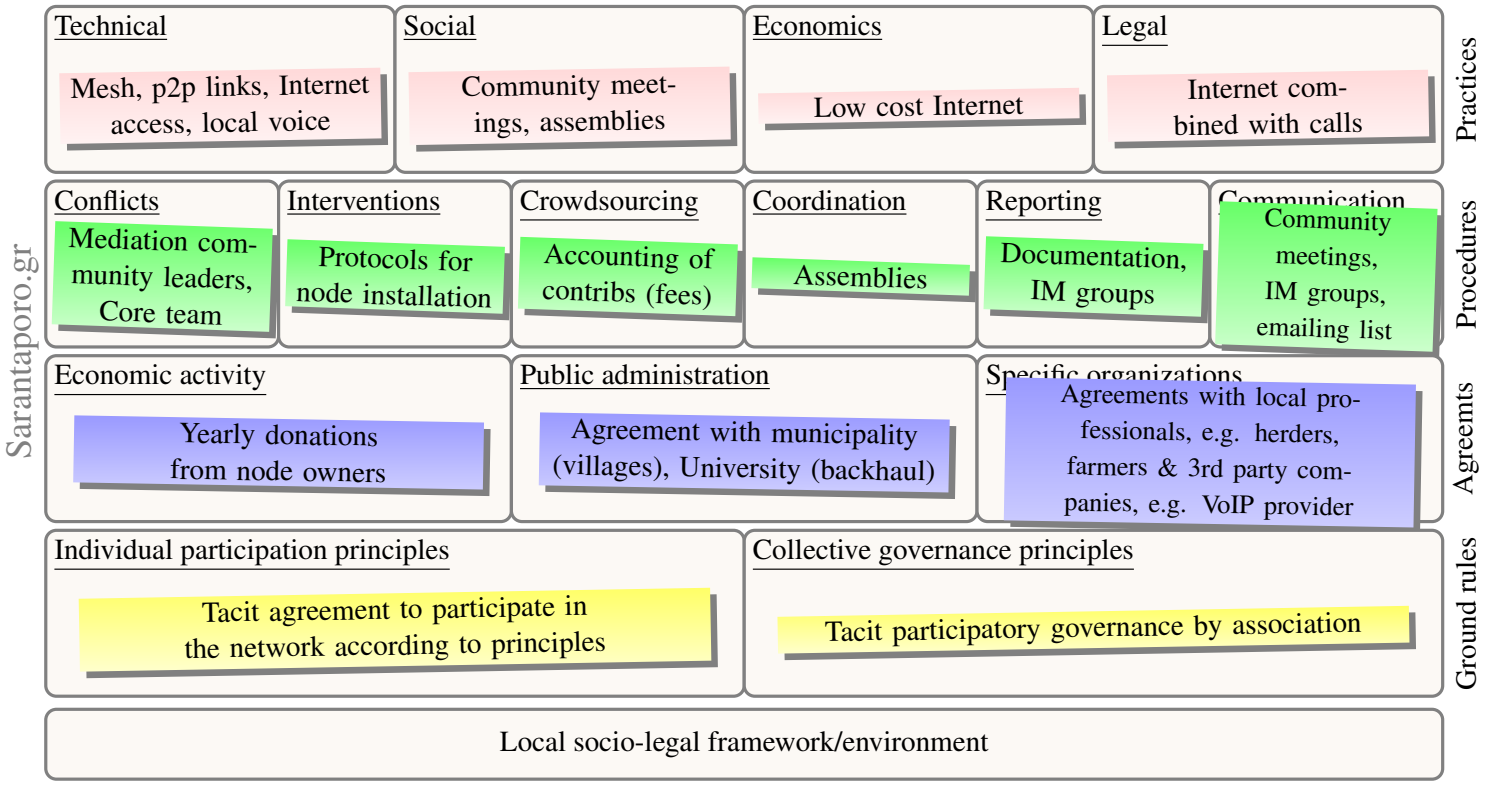

Figure 3.4: The outline of the Sarantaporo.gr internal view

3.3 The case of TakNet and Net2Home

The canvas diagram about the internal organization of Net2Home is presented in Fig. 3.5. The InterLab in AIT supported TakNet and now this is managed by the Net2Home social enterprise. Net2Home provides hardware, training, remote monitoring and economic support to sustain the village networks. Each community has at least a person trained in the past by AIT and now by Net2Home staff (the so called "local engineers") to do basic maintenance of the network and collect usage fees. This local engineer is a volunteer with some interest in technology that, after training and initial deployment of the network by Net2Home staff, becomes the local contact and support their network. The agreements are tacit, not formalized in a (signed) document, and the commitments to host nodes and maintain the network are based on the goodwill and interest of the locals. Net2Home has introduced in-kind compensations such as free Internet service and training. There are periodic (1-2/year) visits by Net2Home staff and AIT volunteers to the communities to support and followup on issues. The contact between local engineers and Net2Home staff takes place in a chat group (using the "Line" app). TakNet is evolving towards a more structured model, where the role of AIT as sponsor has shifted towards the Net2Home social enterprise, a more decentralized structure with more participation from the communities, and driven to operate and expand based on the reinvestment of user fees, complemented with necessary external donations.

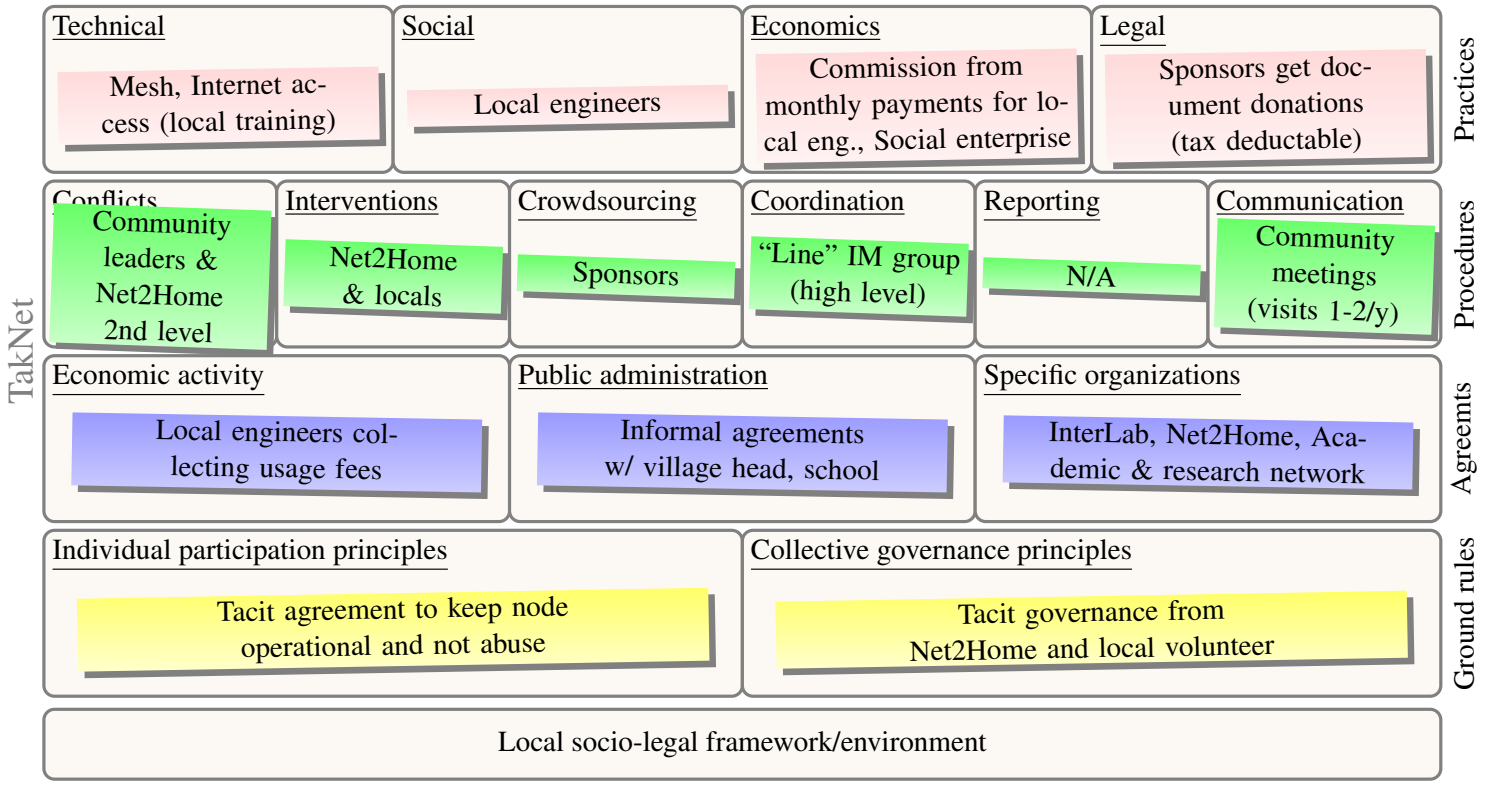

Figure 3.5: The outline of the Taknet internal view

3.4 The case of Zenzeleni

The canvas diagram about the internal organization of the CN in Mankosi is presented in Fig. 3.6. The Mankosi CN is supported by the Zenzeleni Networks Mankosi operator. Zenzeleni offers maintenance and support to the community network, gives technical oversight and legal, administrative and economic support. It also creates relationships with regional, national and international bodies that aid community networks in overcoming common barriers. Zenzeleni Networks Mankosi is constituted as a cooperative, 100% black owned, 33% women owned. It should be sustainable with small contributions from the community networks it is operating, initially the Mankosi area, but more networks are being developed in other areas.

Then, there is Zenzeleni Networks Non-for-profit company (NPC), as an umbrella organization for the local community operators. It aims at *capacity building* to support villages in operating their own network and business; providing hands-on-support aimed at growing local capacity; helping to develop skills to maintain and sustain a company, dealing with challenges to do annual accounting, issue invoices, etc). The NPC provides several key support and functions.

a) *Business incubation* function for the establishment and operation of local CNs, helping in the co-creation, planning and operation of the network, establishing the legal entity, dealing with tax return, manage the ISP contract, work with local social power and decision making issues, and the handling of the complex relation with backpackers' as the only established local business.

b) *Advocacy and awareness* to liaise with regulatory agency, such as GSM spectrum, access different infrastructures; manage processes around public tenders, such as a recently issued tender to connect schools that was assigned to another organization despite the policy of local provider first.

c) *Partnerships* in research and technological development projects that can benefit more than one community and can help to address barriers (financial, tech, legal, among others).

d) *Capacity building* getting involved in partnerships to develop training materials such as videos to strengthen

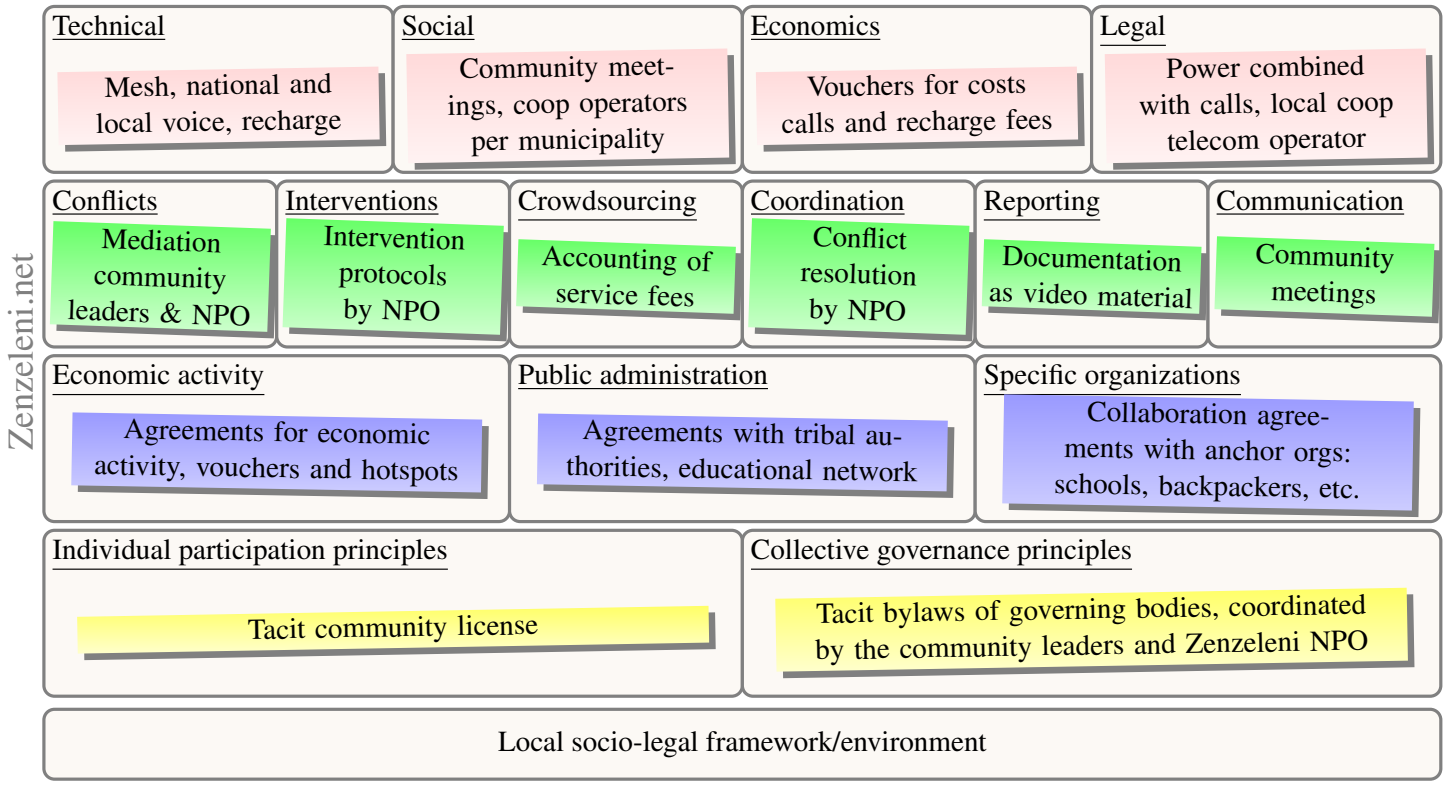

Figure 3.6: The outline of the Zenzeleni internal view

local capacity.

e) *Overshight* to monitor and ensure the network has good quality of operation.

The Zenzeleni model has the competitive advantage of offering cheaper telecommunications services, and most importantly, based on local telecommunication businesses. According to the Zenzeleni business case, the Mankosi Community Network has managed to reduce the costs of Internet access by 90%, voice calls to national numbers by 66% and cell phones recharging by 40% of what is otherwise offered in the area. Additionally, internal calls can be made for free within the community network.

The organizational re-engineering is targeting the expansion of CNs in new nearby areas, as several municipalities in the Mthatha river Valley, part of the OR Tambo District in Eastern Cape, with a total population of about 1.5 million people. Similar to Mankosi there is a extreme unemployment rate, very little economic activity and opportunities and most households live off government grants. Within this setting people spend in telecommunications (airtime, data and phone charging) 20-25% of their monthly income. Given that communities have similar characteristics, equivalent effects are expected, with the expectation that sharing resources can lead to even more important savings and benefits resulting in more socio-economic development.

3.5 The case of B4RN

The canvas diagram about the internal organization of B4RN can be summarized by Fig. 3.7. Given the volume of investment, the effort required to setup a fibre network, and the community connected of about 4000 homes, most if not all ground rules, agreements, procedures and good practices are formalized and documented[1]. In all procedures we find the guidance of the B4RN team, with a staff of about 30 persons, combined with voluntary work and economic investment by individuals from the interested communities, in many cases paid back in

[1] See B4RN resources: https://b4rn.org.uk/resources/

terms of community shares.

The expansion of the model in the home areas, as well as to new similar rural communities far from the home area, is supported by the detailed formalization and documentation of the procedures. This formalization and documentation results is useful to promote the model beyond, as part of the INCA cooperative association of commercial and community operators alternative to the incumbent (British Telecom (BT)), in issues related to competition or overbuilding by BT and Openreach, the branch of BT in charge of expanding broadband across UK, and in interaction with the national telecom regulator Ofcom, and policies from Department for Digital, Culture Media & Sport, defining the UK Broadband plans. These plans focus on fibre expansion and 5G preparation to urban and rural areas, supported by the Challenge Fund under the Local Full Fibre Networks (LFFN) Programme [10].

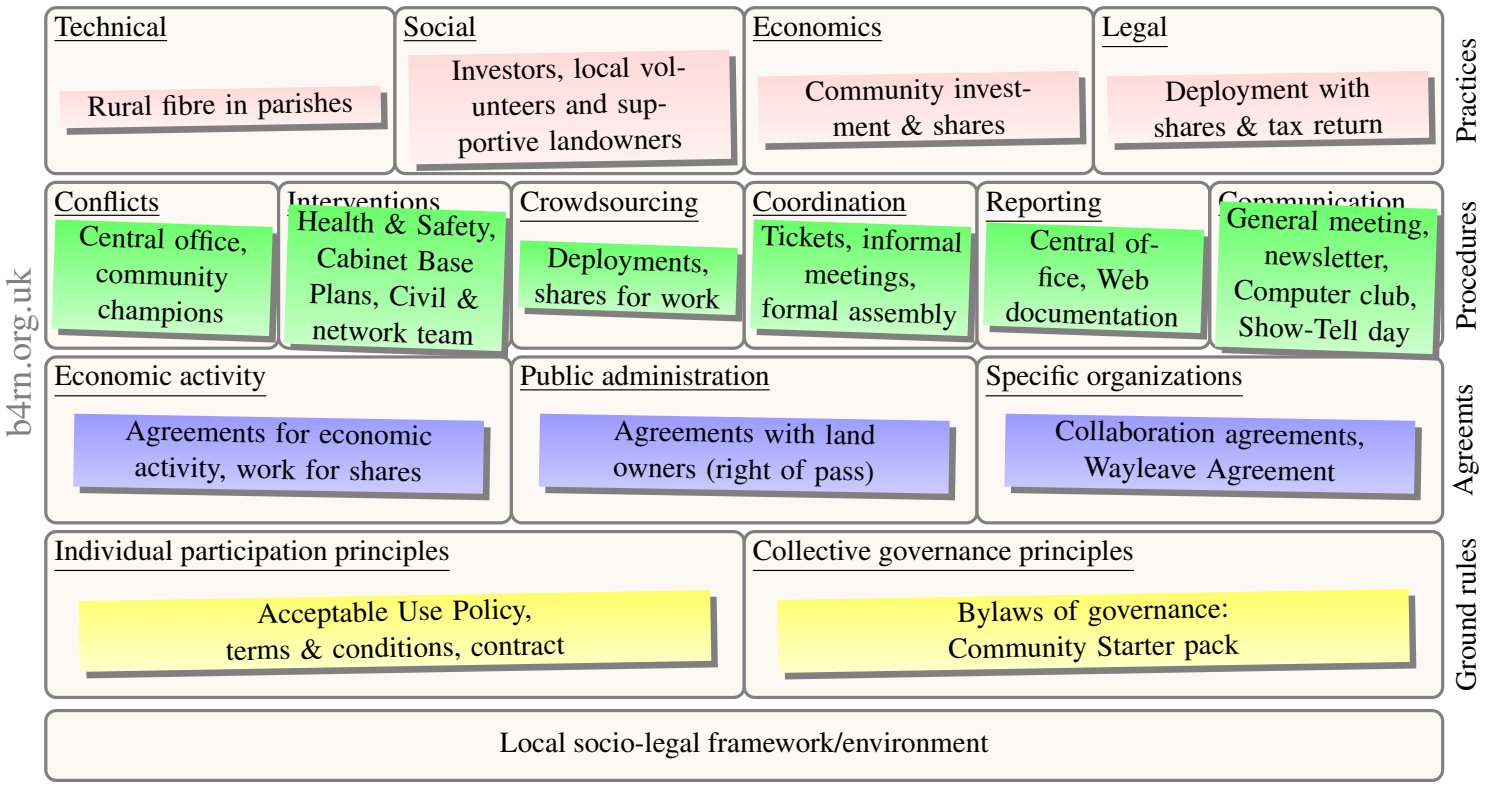

Figure 3.7: The outline of the B4RN internal view

3.6 Comparison and discussion

From the analysis of the CNs described in this chapter, and considering others described previously in D1.1, D1.2 and D1.3, we have found the following features.

The degree of formalization of the external model is directly related to the degree of formalization of the internal model. For instance, the key partners in the external model map into agreements in the internal model. Customer relationships relate to the ground rules and agreements in the internal model.

Several aspects seem to have an influence on the structure of the internal and external canvas. As the scale of a CN grows, the time, complexity and therefore cost of coordination also grows, and coordination can be facilitated by stipulations, like organizational procedures, computer-support tools, and more, as interactions are decoupled from being in the same place and same time.

Different cultures have significant differences in terms of the degree of formality, administrative procedures, traditions about social organisation, political culture, oral versus written forms of cultural expression. Since

CNs emerge from local initiatives, based and adapted from local organizational models as templates, the forms and levels of organisation vary across them and are clearly influenced by the local culture. This somehow shows in the more formalized CNs such as guifi.net or B4RN with a collection of formal agreements and procedures, or less formalised CNs such as ninux, Sarantaporo, Net2Home, or Zenzeleni.

Another aspect is the degree of autonomy of the participants and therefore the decentralization of the network. In the case of very decentralized and decoupled networks (such as ninux or Freifunk), crowdsourcing is the result of individual actions and the size of the network does not create additional work to the governance structure. For instance, in the case of the Freifunk CN, if a urban user shares the spare capacity of her Internet connection, that requires little coordination with the rest of the Freifunk computer network or participants, as long as it follows the principles and values of the community. For the user this is also simple to do as he has only to obtain a recommended access-point device and write the Freifunk firmware. The software will automatically implement the rest. In contrast, in a rural Wi-Fi network, point-to-point long-distance links require two members to point directional antennas towards each other. The traffic in one corner of the network may require to upgrade some of the backbone nodes and links to cope with the increasing traffic in a more populated network or to increase the resilience of the network. That requires coordination to decide on a fair way to contribute resources from all the participants in the network that can benefit or be affected, and not only by the few directly involved in each side of the congested links. In the first case, the network could be seen as the aggregation of nodes, with little interdependence and many times without inter-connection, while in the second, the network infrastructure, as it grows, becomes a commons resource to preserve as it is critical to everyone to receive the benefit of wider connectivity.

The growth rate of a CN appears to be related to its degree of formalization. The easier to setup a new node and the more automated it is results in reduced barriers to entry and less burden to become an operational node. Procedures and automation of management helps along the growth, as it simplifies, standardizes and reduces the cost of transactions. As a community understands an issue or procedure and finds a way to address that, it seems reasonable to decide on procedures to deal with equivalent cases, instead of discussing and deciding collectively for each repetition. One example of that is the economic compensation system in guifi.net or the shares for work in B4RN, where the costs and procedures are stipulated and the management is automated. Similarly, as CNs expand over a wider area, the opportunities and costs of meeting each other makes frequent face-to-face interactions unfeasible. That requires formalisation and standardisation of procedures so that can be implemented as computer-support tools to facilitate the interactions and coordinate decisions. The result is more efficient and less costly actions from a reduction of the amount of interactions and the cost of decision making. This is the case of most CNs, but particularly visible in the development of guifi.net, in the transition from TakNet to Net2Home, and in the ongoing expansion of Zenzeleni to new communities.

Formalization is also related to the level of required investment and the objectives of infrastructure resilience. Networks based on fibre require orders of magnitude more investment and network planning prior to a deployment or lease of dark fibre, and that result in more formalization of the commitments related to investments and the return of these. In addition, the high cost of the deployments and the amplified effect of any fibre cut result in less intrinsic resilience that has to be compensated by costly investment in redundant fibre, particularly for regional interconnection. This is clearly the case of guifi.net and B4RN.

The existence of professional activity, combined with volunteer activity, implies that a network is creating direct local socio-economic benefits in the form of direct jobs. The existence of the jobs that rely on the commons infrastructure, such as in the case of guifi.net, B4RN, Zenzeleni, Rhizomatica, and in some degree in Net2Home) usually brings more care and resources to preserve that commons, and therefore provides better connectivity to its users (more stable, faster and reliable).

Sustainability, in terms of viability and resilience, is also relevant from the internal organizational perspective. It has implications in the organisational and governance design, as well as technical, social, economic and legal aspects, covered in the internal representation of each CN. Table 3.1 shows a list of CN that relate the legal form of the organizations that represent the CN, the kind of participants in the membership, and how these

CN	Legal form	Membership	Contribution
AWMN	AWMN Union	Individuals	Individual (infrastructure), voluntary work
B4RN	Community Benefit Society	Individuals	Service fees, investment (shares), voluntary work
Consume	None	Individuals	Voluntary work
FFDN	Non-Profit Organization plus member organizations	Member orgs, each with own individual members	Service fees, donations, voluntary work
Free2Air	Incorporated Legal Company	Members	Service fees
Freifunk	Non-Profit Organization, but loose membership	Members, Public Institutions	Individual (infrastructure), voluntary work
Funkfeuer	None	Individuals	Individual (infrastructure), voluntary work
guifi.net	Guifi.net Foundation	Individuals (volunteers, professionals) and organizations	Individual (infrastructure), voluntary work, sometimes maintenance or service fees, donations
Ninux	None	Individuals	Individual (infrastructure), voluntary work
Rhizomatica	Non-Profit Organization	Member community networks	Members (infrastructure and service fees), national and international organizations, donations, voluntary work
Sarantaporo.gr	Non-Profit Organization	Core team (individuals), members (individuals), partners (organizations)	Core team and members' annual fees, extra services fees, voluntary work, participation in European research programs, donations, awards
TakNET Net2Home	None, sponsored by AIT, recently reformulated as a social enterprise (Net2Home)	Individuals	Members, Private Institutions, THNIC Foundation, European Union, ISOC, among others
TFA	Non-Profit Organization	Individuals	Voluntary work, Foundations, Public Institutions, Donations
Wireless Leiden	Non-Profit Organization	Individuals	Individual (infrastructure), voluntary work, Public/Private Institutions
Zenzeleni.net	Formal Telecom Operator	Tribal authority	Individual (service fees), voluntary work, Public Institutions

Table 3.1: CN defining internal organizational aspects.

participants can contribute to the CN.

Many of these cases have been formalized out of the context of a specific CN, and isolated in the form of patterns and anti-patterns. These were defined initially in D1.3 and are discussed and compared further in the next Chapter 4.

4 Mapping of organizational patterns in CNs

The organizational patterns and anti-patterns were identified and described in D1.3 [3]. The idea of defining organizational patterns for CNs originated from the idea of a *design pattern*, the re-usable form of a solution to a design problem [11]. Organizational patterns [12] and pattern languages can help people think about, design, develop, manage and use information and communication systems that more fully meet human needs. The patterns and anti-patterns identified cover most of the relevant elements of the generic internal view identified before, as Fig. 4.1 shows (patterns in blue, anti-patterns in orange). An *anti-pattern* is a common response to a recurring problem that is found to be usually ineffective, and risks being highly counterproductive. This idea is well known and used in software design but also applicable to organizational patterns. Here we extend the analysis in D1.3 with a mapping of these patterns and anti-patterns with respect to the CNs of reference in our work.

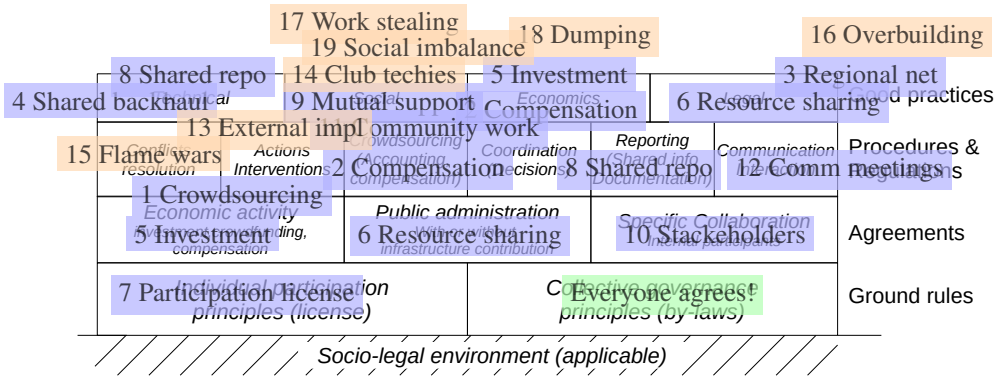

Figure 4.1: The mapping of patterns to the generic internal view.

Table 4.1 shows a mapping of the patterns as they apply or not to CNs, and the typical issues that may appear as a result. Similarly Table 4.2 does the same for the anti-patterns.

As it can be seen, some patterns are not applicable to certain CN cases for different reasons, while others may apply. The patterns and anti-patterns come as a result of lessons learned by organizations (organizational learning) but somehow extracted from a given organizational context. The lessons learned are easier to apply across CNs as they can be described in relative isolation from any given complex internal and external organizational models. The level of experience of one CN can result in a recipe that others can reuse. The usefulness of these patterns is that they contain useful information about how to handle or prevent them.

	Not applicable	Applies	Issues
Patterns			
Crowdsourcing	None, defines a CN	All	Necessary for shared resources and social inclusion
Economic Compensation	Freifunk, ninux	guifi	Critical to economic sustainability in larger CNs
Regional network	Local CNs	guifi, B4RN, HUBS	Critical for regional exchanges
Shared backhaul Internet	Not a purpose for AWMN	guifi, B4RN, HUBS	Coordination and cost sharing is critical
Community Investment – Shares and loans	Freifunk	Participants (B4RN), donors (Zenzeleni), eXO	Compensation system in guifi (decentralized), interest and return of community shares in B4RN
Legal/regulatory mechanism for cooperative resource sharing	-	guifi, Rhizomatica, B4RN	As CNs grow, they can be perceived not just as promoters or facilitators of connectivity but as competitors to traditional ISP. Requires rethinking of economic model and policy work
Community participation agreement	Freifunk (informally defined)	guifi (XOLN), B4RN (included in the contract), ninux (own, picopeering based)	Value of the legal enforcement of the "agreements" as done by guifi and B4RN
Shared network infrastructure information	TakNet	Nearly all, given the need to represent it for many processes	Interoperability across CNs and tools
Mutual support	None, defines a CN	All (learning and social bounds)	Centralization, professionalization, community champions
Stakeholders: volunteers, professionals, service providers	Freifunk (homogeneous)	guifi (volunteers, professionals, gov), B4RN (land owners, professionals, volunteers, customers)	Diferences in interests, differences between volunteers and professionals
Community work	None, defines a CN	All	Recognition, compensation, retribution, incentives
Community meetings	None, defines a CN	All	Decentralization: local groups for experience sharing and coordination of community work, but sense of belonging to a larger group

Table 4.1: Organizational patterns in CNs.

	Not applicable	Applies	Issues
Antipatterns			
External implementation (of network infrastructure by external agent)	None, defines a CN	Faced in some degree by Sarantaporo.gr, TakNet/Net2Home, DEF	Sense of ownership, sense of reliance and responsibility
The club of techies	None, as technology determines initial feasibility	guifi, ninux, but all in some degree	Gender, expertise gaps, that become barriers
Flame wars	Unavoidable as groups evolve and grow	guifi, AWMN	Disillusionment
Overbuilding	Underserved areas such as Zenzeneleni, DEF, Rhizomatica	B4RN, guifi	When services are comparable or better than incumbent in quality and coverage of certain areas
Customer stealing	Uncommon, related to the idea of having pure "customers"	guifi	Given its model of professional operators, solvable by specialization or regionalization
Dumping – Downward spiral of prices below cost	Uncommon	guifi	Given its model of professional operators, risk of economic unfeasibility when given below the "at cost" model
Social imbalance	Unfortunately true, despite being an objective	All	There is an effort to balance, intrinsic from the techie world

Table 4.2: Organizational anti-patterns in CNs.

5 Analysis of organizational change in CNs

With the term *re-engineering* we refer to work done with selected CNs to support the organizational evolution to reach maturity, considering the patterns and anti-patterns, as well as the governance instruments identified in our work (D1.3 mainly). All these changes may finally exhibit in the summarized representation that are the outside and inside views of each initiative.

This work is part of a process of dialogue, follow-up and collaboration with diverse community networks. We discuss with them to identify the risks, aims, and metrics for evaluation of impact. Here we report about the process, the outcomes of the adaptations, and the impact during this initial period. Organizational change take time. The pace is defined by each community, and given the reliance on volunteers, spare time, and community decisions, we apply the principles of Open Space Technology: Creating an environment where things are possible, and *"Whatever happens is the only thing that could have"*[1]. We do have control on our participation and follow-up process, but we do not have control on the timing when communities may or may not adopt practices, take decisions and implement them. We rely on the feedback from our contacts to assess the impact. As mentioned in the introduction of this report, our action-research work involves several members or representatives of different communities. Therefore, more mature outcomes can be reported at the end of the project, in a year time.

The opportunities for re-engineering identified previously in D1.3 are the following:

- The investment model for guifi.net, inspired by the experience of B4RN.
- The economic sustainability models for W4C in the communities and its formalization, and for the regional network interconnection in the case of Rhizomatica.
- The development of the compensation system inside the eXO community in Barcelona, in parallel with the introduction of the compensation table in the metropolitan area of Barcelona.
- The formalization of the ninux governance, including valorisation of voluntary work and incentives.
- Increasing public accountability and more balanced participation of minorities in the FDN and Tetaneutral communities, part of FFDN.
- Support the design and implementation of a federation for the replication of the Zenzeleni CNs to more than 10 similar communities in the region. That includes the development of a governance model for each, for the regional backbone network interconnection, and for the provision of shared Internet connectivity.

Furthermore, we have consolidated a collaboration of netCommons with TakNet/Net2Home, and we explore with them the development of an inside and outside canvas model and the corresponding organizational reengineering in the Net2Home model.

In Chapter 6 we focus on the description of a detailed re-engineering of the guifi.net organization and governance model to support community clouds, based on the organizational framework for the network infrastructure developed in WP1 and reported in D1.1 and D.12, and the development and experimentation with Cloudy in WP3 (see D3.2 [13] and D3.4 [14]).

Regarding the metrics to quantify and qualify organizational change, we can look at several dimensions, all related to social impact in the target population (the "customer segments"). Typical metrics include the size (like number of nodes, node density per geographic area, area served), the stakeholders (diversity of them, generation of economic activity and professionalization), quality (level of satisfaction, cost effectiveness such

[1] Designed for "organization transformation": https://en.wikipedia.org/wiki/Open_Space_Technology

as connectivity costs with respect to disposable income), sustainability (track history of evolution to adapt to environmental changes, maturity and transparency of the economic model, level of formalization, scalability), openness (real opportunities for participation in the governance, such as number of people actively involved in the governance of the organization and its organizational development).

Community	Risk	Goal	Ongoing
guifi.net	Slow development of infrastructure	Promote planned & Quicker deployments	Pilot under development with new investment model
TakNet Net2Home	Unsustainability	Implement compensation system	Pilot of usage fees, evolution to a social enterprise structure: Net2Home
ninux.org	Anarchy	More structured governance	Reform of the community participation agreement to provide stronger committment
Zenzeleni.net	Lack of economic and technical resources	Expand to nearby communities	Initial expansion beyond initial community
Rhizomatica	Scalability	Organic growth in rural indigenous communities of nearby regions	Consolidation of the model, planning & priorization of initiatives
FFDN.org	Heterogeneity	Public accountability	Involve and support more diverse participation
B4RN	Side effects from national broadband plans (fibre and 5G)	Organic growth in the proximity, rural environment	Increase of resilience by infrastructure redundance and rapid response

Table 5.1: Organizational change in some CNs

Regarding the organizational re-engineering initiatives, Tab. 5.1 illustrates the risks faced, the goals of the initiative and the ongoing processes. Furthermore, we have classified initiatives into three groups according to the level of development: under consideration, under implementation, and under validation.

5.1 Under consideration

FFDN: *Public accountability and more balanced participation of minorities in the FDN and Tetaneutral communities*. It will be discussed in May 2018 during FFDN's next general assembly. In preparation for the next general assembly, the volunteers have prepared a spot that will accommodate people with disabilities, which was not the case before.

Rhizomatica: *Regional network interconnection*. The ongoing discussion with Rhizomatica, a social enterprise working with rural and indigenous Global System for Mobile Communications (GSM) community networks in Oaxaca (MX) and nearby areas, has been mutually useful. They have used their own BMC in the past to explain the business model of community cellular telephony to rural and indigenous communities that were considering starting a community operator. This was very useful in the refinement of our external canvas representation. The development of interconnection across each cellular community will allow the communities to share the costs and the benefits from shared Internet and telephony gateway services. After a yearly planning phase in December and January, we will see how the organizational and governance results formalized in netCommons can contribute to the work plan of Rhizomatica in 2018.

W4C: *Economic sustainability models*. Digital Empowerment Foundation (DEF), ISOC and APC organized the first annual Community Network Summit 2017 in India. The topic focus is described by the subtitle

of the event: *"Understanding social & economic sustainability approaches of community networks in Asia Pacific"*. The regional focus was on India and the Asia region. netCommons was represented by Carlos Rey-Moreno, member of Zenzeleni. He organized a session about CN business models, where the external model (BMC) diagrams developed in D1.3 were presented (more on this event is indluded in the dissemination deliverable D6.2) and the participants developed their own organizational diagrams, collected in a report [15]. One general impression is the need to define indicators and collect data to measure the impact and the sustainability of the initiatives, that most of them seemed to be pilots and trials rather than mature projects. An ongoing collaboration between our research team with ISOC, APC and DEF will allow to organize a future training session on these organizational and governance topics in 2018. In fact, the three more developed CNs in this workshop are already in different degrees of collaboration with netCommons: Zenzeleni, Quintana Libre - Altermundi, and the CNs sponsored by DEF.

5.2 Under implementation

Zenzeleni: *Federation for the replication of Zenzeleni*. The Mankosi network infrastructure, operated by the Zenzeleni community operator, has consolidated in his community and has received national and international recognition this year. We are working with them to support the plans to expand to many other similar communities around. This requires that Zenzeleni, as a telecom operator, can find a way to expand its network to new communities, which in turn requires the local groups to plan and deploy the network in each community with assistance from Zenzeleni, and that a regional backbone network is developed to interconnect the communities across them and share a common Internet access.

TakNet/Net2Home: *Development of an inside and outside canvas model*. The TakNet community network [8], supported by the Asian Institute of Technology in Thailand, expressed interest in implementing organizational and governance reforms to increase the autonomy and sustainability of the community meshes in diverse rural areas of the north of Thailand. Collaboration with two representatives (Kanchana Kanchanasut and Adisorn Lertsinsrubtavee) meeting in diverse international events has facilitated the dialogue. The plan is to continue the collaboration with AIT and Net2Home started in the second semester of 2017 along 2018, and be able to report the effects at the end of that year.

eXO: *Implementation of a local compensation system*. The local guifi.net association in Barcelona has advanced, albeit slowly, in the implementation of the compensation system. The prerequisite for a successful compensation system is the traceable/auditable reporting about contributions and consumption by all local participants. eXO has implemented a comprehensive monitoring system (a private and a public one[2]), a register of voluntary work, and an accounting system for CAPEX and OPEX contributions. The detailed accounting combined with the steady growth of the association has resulted in the initial implementation of the compensation system with the guifi.net Foundation for the Internet backhaul. As a result, the eXO already participates in the compensation table for the Internet carriers commons, compensating the consumption of Internet connectivity, reported by both the traffic monitoring of eXO and the guifi.net Foundation, not only with fees but also considering community effort.

ninux: *Revision of the governance, valorisation of voluntary work and incentives*. The community license in ninux, based on the pico-peering agreement, was discussed and modified with more stringent rules in the last community assembly (*ninuxday*, last weekend of November), which introduce incentives and obligations of responsiveness to the participants to help improve the quality and reliability of the network infrastructure. Members of netCommons are looking at the agreement under a legal point of view. Following with the previous discussions, there was a discussion on the (non existent) governance strategy, and Leonardo Maccari (researcher in netCommons and member of a local ninux group) will present and discuss in the next community assembly elements and alternatives about governance to help in the devel-

[2] http://tomir.ac.upc.edu/qmpmon

opment of a governance model for ninux. This work is planned to be done in 2018 and the community is eager to do it. The development of a governance model is a good basis to also develop the valorisation of voluntary work (as described in D1.3) and additional incentive mechanisms (as described in D2.3 [16]).

5.3 Under validation

guifi.net has been working closely with netCommons. The most significant results are the following:

Community cloud model: Formalized during end 2016 and 2017. See Chapter 6 for details.

Investment model: The investment model, which in 2015 received the European Broadband Award of the European Commission (EC), is aimed at ensuring a proper distribution of the costs and benefits of the infrastructure according to the contributions and usage. As a result of the collaboration, the *economic compensation system* has been consolidated and the corresponding *sanctioning regime* developed and is being implemented. These developments have been put in practice in the Garrotxa county[3]. See below for further details. Other CNs also have rather developed investment models, such as the case of B4RN, which has been helpful in the design of this model.

Ordinance: The municipal ordinance model, the basis for agreements with municipalities, although much more ambitious, is now fully aligned with EU directive (EU/61/2014) for cost reduction and with the Royal Decree of transposition last September (RE/330/2016). The work is a result of a question to the European Parliament (petition 1230/2016) regarding the Directive on cost reduction over resolution deadlines and positive administrative silence. The ordinance is pending adaptation to the royal decree, but can be completed on request from any public administration interested. The guifi.net Foundation brought two legal actions to defend the rights of the participants to access the public infrastructures. The fist was brought to the Catalan competition authority (ACCO) in May 2017 against the Catalan Government for a case of discriminatory fees[4] and the second was brought to the Spanish national regulatory agency (CNMC) on December 2017 against the Spanish Government[5]. The first was successfully resolved and the second, which was encouraged by the European's Parliament answer to the aforementioned question, should be resolved in early 2018.

Development of the platform for the management of fiber: This platform is a critical part of the intervention mechanism for planning, deployment, operation and maintenance, with the following attributes: systematic communication with public administration: petitions, reports, etc. Unified inventory (as established by the ordinance, and that ideally should be done instead by the public administration). Exchange formats for compatibility with the unified inventory.

The **Xafogar project**[6] is a flagship project in the Garrotxa county for deploying fiber across the region to every single home excluding the county's capital (Olot, already covered by standard operators) lead by the county's *Consorci de medi ambient i salut pública (Consortium for the environment and public health)* and the guifi.net Foundation. With a total budget of 10M€, the first phase now being executed (0.7M€ out of 1.5M€ already invested) it comprises the backbone as seen in Fig. 5.1[7] and the deployment in some of the villages (with penetration rates over 90%, e.g. Tortellà).

The two main success factors of XAFOGAR are a true and honest involvement of a public administration and a trustworthy investment model. The public administration contributes in leading, coordination and dissemination tasks but not in funding. The investments come from either direct beneficiaries or investors (usually local operators and, in less degree, municipal governments that lend small amounts of money at a standard interest to trigger deployments).

[3] A 734.5 km^2 county in the north of Catalonia: https://en.wikipedia.org/wiki/Garrotxa
[4] Web site (catalan): https://fundacio.guifi.net/Blog?id=25
[5] Web site (catalan): https://fundacio.guifi.net/Blog?id=30
[6] Web site (catalan): http://www.xafogar.cat/
[7] Source: http://www.consorcisigma.org/

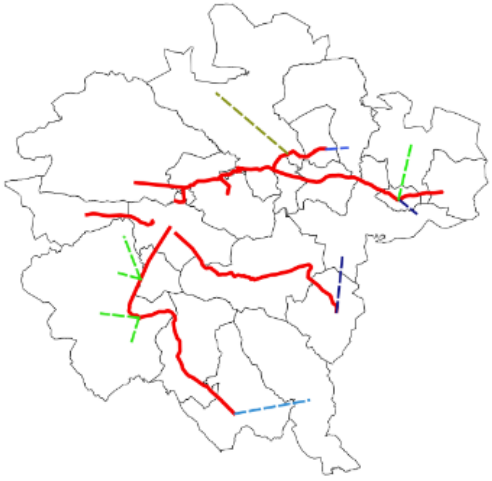

Figure 5.1: A map of the fibre backbone in the Garrotxa county

The incentives for investors are the following:

Priority at the time of connecting. The process of connecting users with optical fiber is complex, expensive and slow. It will take some time, and we make an effort to connect first and prioritise those who help to finance the network or pay the cost of their connection, compared to those that are waiting for the connection to be financed through the sum of fees that will be paid each month with the service.

Tax relief. Since the network infrastructure belongs to all and is formally guaranteed through the guifi.net Foundation, which is a not-for-profit entity of general interest, the contributions in infrastructure and duly accredited maintenance can benefit from the tax reliefs that it envisages the Spanish law 49/2002 on the tax regime of non-profit entities and incentives for patronage (tax deduction between 30 to 75%).

Return on investment. For those who contribute beyond the cost of their connection, there are several mechanisms for returning the investment, either with discounts on the service or returns as users are incorporated.

XAFOGAR is a successful project that can be used by other public administration as a reference and that has produced methodologies and software tools ready to scale 10 times at least.

6 Community Clouds in guifi.net

As a result of the development of an organizational framework for community networking infrastructures (D1.2, D1.3), the development of the Cloudy distribution (D3.2 and D3.4 in WP3), and the ongoing pilot in guifi.net, we have developed an organizational framework for community clouds as open commons. This work has been a joint activity between netCommons research in collaboration with the guifi.net Foundation that has contributed a lot of time and ideas to develop this model[1]. The extension of the organizational framework beyond the networking service to include computing and storage resources, platform services and application oriented services is a major contribution to expand the organizational and governance model of CNs to a new domain, cloud computing, and a timely basis for pilot activities with Cloudy in the third year of the project, where the model can be tested and revised from the experience of using Cloudy in other communities.

6.1 Community Clouds

The generic term Community Clouds (CCs) refers to cloud systems designed to address the needs of a community [18]. The CCs have the potential to solve unattended needs of CN members and improve the efficiency of some existing services (mostly latency, performance, cost, and availability of services such as web, video, and data content) through the benefits of the cloud paradigm. These come mainly from the flexibility and savings that elasticity, pooling, and on-demand self-service bring in terms of performance, cost, and availability from the use of multiple alternative nearby servers in the same community or access network. The technical knowledge of the participants and their openness to research and innovation are other positive factors in this regard. The CCs deployed locally can bring benefits to communities and can address unattended needs, such as latency-critical applications; critical local sensing and control services that cannot rely on non-existent, fragile, or expensive Internet connectivity; local storage services with customised access control policies for content; applications for emergency and disaster scenarios; and privacy and data-security sensitive uses, where remote services may not be trusted or they gather, expose, or exploit sensitive data.

The CCs describe a model that can be organised in diverse ways, such as a competitive free market, a firm, a hierarchy, or a cooperative model[2]. We claim that CCs can be organised as open commons, similarly to how CNs organise [2, 19]. The CNs offer a suitable model for CCs as open commons to emerge, given 1) the open and collaborative nature of CNs and 2) the piggybacking of pre-existent IP network infrastructure. The local management of CCs creates more opportunities for access to the cloud infrastructure adapted to the local socio-economic conditions, in terms of both production and consumption of resources and services. Thus, they have the potential to involve further participants and leverage new spaces of relationships, bringing new opportunities to entrepreneurship and innovation for more people. In the context of CNs, the capability of CCs to generate local value translates into incentives to strengthen the existing networks and to bootstrap new ones, especially in developing countries.

Here, we explore *CCs as open commons*: open as extensible user-driven (self-provided) clouds formed by community-managed computing resources, where the infrastructure as a service (IaaS) and platform as a service (PaaS) cloud components are organised as common-pool resources (CPR), on top of which the users deploy software as a service (SaaS) to consume resources and platform services or provide application services for free or for a fee.

[1] Most of this chapter is part of a journal paper under review at the time of this writing [17].

[2] In fact, Oliver E. Williamson and Elinor Ostrom shared the Nobel Prize in 2009 for the analysis of economic governance, the first for the boundaries of the firm, and the second for the governance of commons.

We have analysed the success case of the guifi.net digital infrastructure managed as an open commons, and developed a framework for the structure of a CC.

The interactions with the community to develop this model took place in several meetings with members of the guifi.net Foundation, and focus groups in several weekly community meetings. The group discussions were around the planning, co-design, transformation, and result phases of the design. We used a combination of larger meetings to collect diverse opinions, and small group meetings for analysis and decision making. These interactions were useful to better understand the needs and preferences, to obtain feedback and to refine the community cloud model and its governance instruments.

The resulting outside view of the CC CPR in guifi.net is as follows in Fig. 6.3.

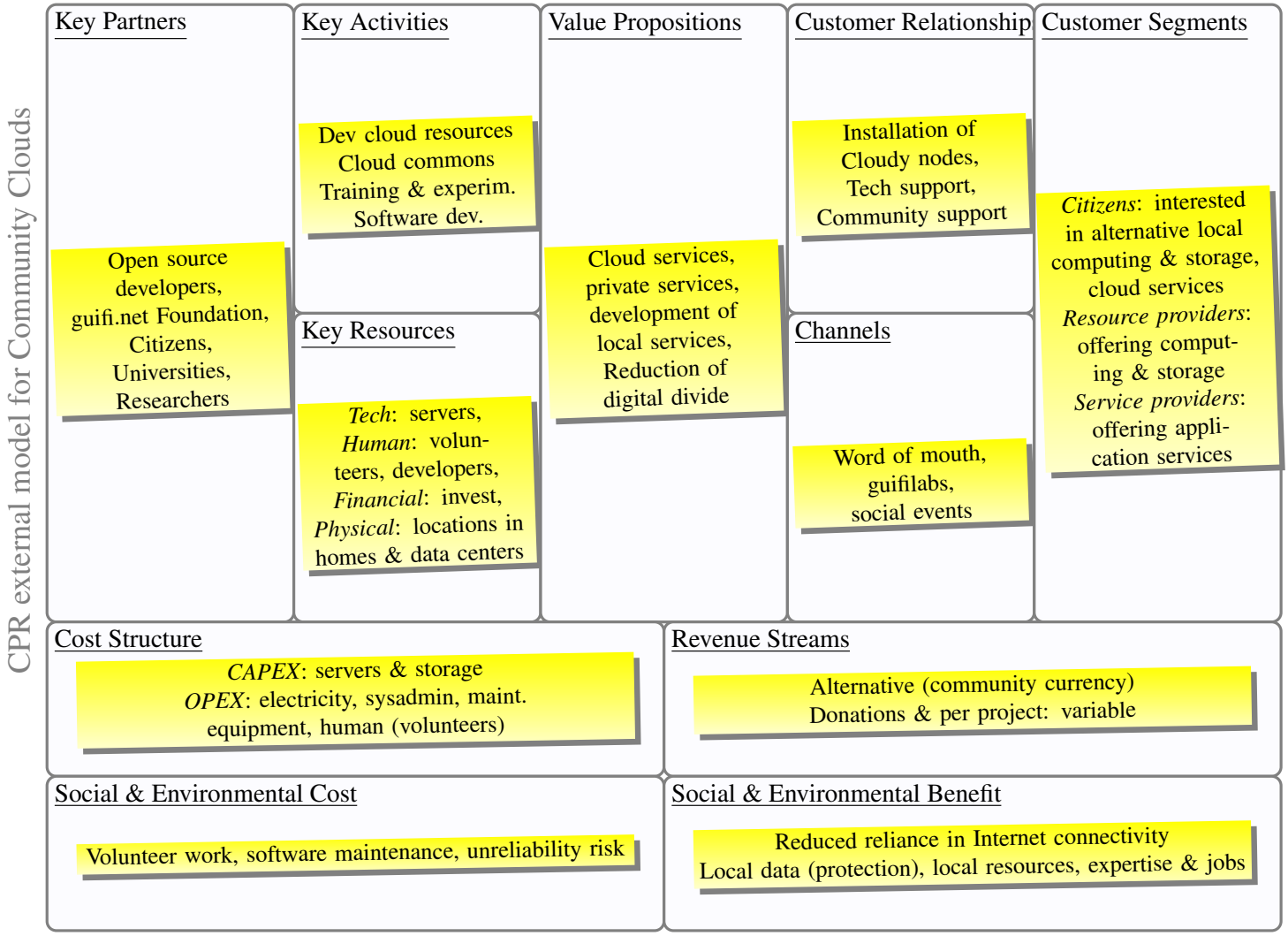

Figure 6.1: The canvas outline of the CC CPR in guifi.net

6.2 Framework for Community Clouds as Open Commons

As with CN resources, cloud resources can be developed as open CPRs, and for that we have build on the analysis in Chapter 2 and Chapter 3. In the case of a CC, the core resource is nurtured by the diverse contributions of networking, computing, storage, and service elements that the participants deploy to expand or improve the CPR, and the fringe unit is the services they obtain. An architectural comparison of clouds to networks in the

context of CPRs,[3] leads to the following main differences:

Diversity of building elements For a CC, the building elements are more differentiated than in the underlying network. In addition to the physical level where host devices (servers) provide computing and storage capacity and the network provides connectivity, the cloud software stack components (Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS)) are also building elements that provide diverse additional services (e.g., resource allocation and user authentication). This higher complexity has a direct effect on the CPR model, architecture, and implementation, as described further on.

Inter-dependency among resources At the network level, the CPR is a primary infrastructure, that is, it has no inherent dependencies on other infrastructures. This is not the case for the cloud, which inherently depends on network connectivity for the interaction among building elements and users. In addition, there are inter-dependencies among physical resources with services and across different services (e.g., a PaaS depending on IaaS). Moreover, some resources or services are more critical or demanded than others. Thus, the consequences of the deployment of an infrastructure with such dependencies must be studied not only from the viewpoint of usage/demand/traffic of a specific class of resources but also from a holistic approach. This will allow us to answer questions concerning the following: the complexity of interaction and balance across classes of cloud resources, resource bundles required in services, congestion management and fairness across services, and the influence of related infrastructures, such as the underlying network, the power grid, the environment, or the socio-economic aspects of the community of users and organizations. The answers to these questions have a direct effect on the design of the CC software architecture and particularly in the mechanisms for service allocation and discovery used to select service instances, described in WP3 deliverables.

Boundaries of the CPR The rule applied for the network infrastructure level, *the guifi.net community takes care of the infrastructure as a CPR, the content is left up to the users* (considering content to be pure usage and therefore external to the CPR), can also be applied to a cloud. However, the criteria to determine what must be considered external (as content) and what is considered infrastructure are flexible at the design level (see Figure 6.2 of Section 6.2.1) and might not be so obvious at the implementation level. In hybrid clouds, where in-house (private) infrastructure is complemented with external (public) infrastructure, that boundary is clear; internal owned vs external rented and therefore metered. In our context, the main distinction depends on the nature of the exchanges that can be done cooperatively (to cover the costs declared) in a CPR, or competitively (at profit, with market prices ignoring the costs) in a commercial market, and even for free for some amount of exceeding resources. The different nature of the exchanges has a direct effect on the application of the CPR model to the governance of the different cloud layers, described in Section 6.2.1.

As for any other open CPR, the implementation and sustainability of a cloud requires effective rules and tools for the governance, maintenance, expansion, etc. In the following sections, we discuss our proposals to meet these challenges and compare to the network infrastructure case, paying special attention to the differences just outlined.

6.2.1 Community Clouds as Open Common-Pool Resources

The fundamental principles of guifi.net also apply to a CC. It must be fully inclusive, that is, it must ensure the openness of access (usage) to the infrastructure, and the openness of participation (construction, operation, and governance) in the development of such an infrastructure and its community. The application of these fundamental principles results in a CC resource and service infrastructure that is a *socially produced collective good* governed as a *CPR*. Likewise, the high-level design requirements (e.g., standardization of resource

[3] The comparison of models, conceptual and system architectures, and identification of requirements was part of Clommunity (EC FP7-317879).

management, interoperability of individually contributed resources, and ease of participation) are equally valid.

With a set of essential IaaS and optional PaaS cloud services given as a CPR, enhanced and aggregated SaaS services can be built upon them and be offered on a cost-sharing or for-profit model. Similar to how the network CPR reduces the entry barrier (through transparency, network neutrality, and cost sharing, resulting in reduced CAPEX and OPEX costs) and enables the market niche of proximity services, a cloud infrastructure held as a CPR appears to contribute to making cloud computing even more accessible for entrepreneurs or Small and Medium Enterprise (SME), for profit or not, as described next in general.

Scenarios for CCs

Figure 6.2 illustrates different scenarios for CCs. In CNs like guifi.net, although the network infrastructure is a CPR, the network can be provided according to different models by single or multiple commercial providers in a market [20]. Over the network layer, for the cloud service layers (i.e., IaaS, PaaS, and SaaS), different combinations of service provider solutions (SP) and community solutions (CS) are possible to satisfy the users' needs.

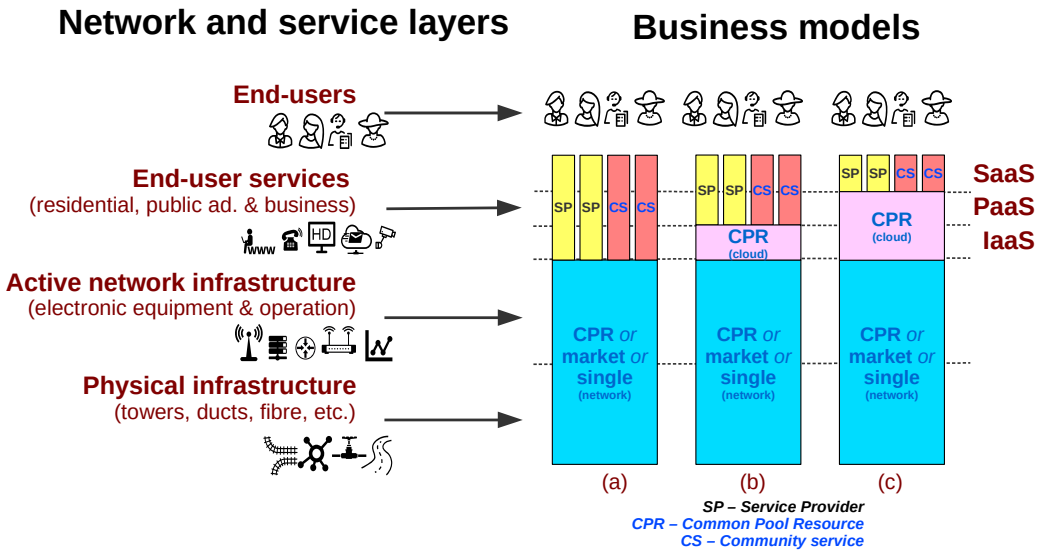

Figure 6.2: Alternatives in the layering of community cloud service provision over any kind of network service.

The scenario on the left of Figure 6.2 (a) corresponds to the *vertical integration* approach, the most widespread implementation, with no cloud CPR. In this scenario, a dedicated hardware deployment and software stack must be developed and maintained without the possibility of benefiting from any cooperative resource federation among different providers. Examples of that are the well-known commercial cloud providers, or private clouds, the combinations (hybrid) without horizontal integration at the IaaS or PaaS layers.

Scenario (b), the *infrastructure commons*, addresses a novel cloud scenario where the resources for the IaaS, such as virtualised or bare-metal computing, storage, or networking resources in community locations like cabinets, warehouses, or mini data centres, are provided by the participants and pooled cooperatively. One of the benefits for such a case is inherited from the characteristics of the cloud resources on which the IaaS is built. For instance, a geographically distributed heterogeneous IaaS enables new types of services that cannot be provided by centralised data centres. The proximity to its users translates into lower latency, lower network partition sensitivity, and higher trust, among others. Examples with various levels of cooperation are the ExoGENI or EGI, mentioned in the related work, and the Brighton Digital Exchange[4], a cooperatively-owned and run data

[4]BDX: http://bdx.coop/

centre, where member businesses can peer and co-locate equipment and provide services to Brighton businesses and the world.

In scenario (c), the *platform commons*, commercial or community organizations provide end-user services through cooperative community-based IaaS and PaaS. In this case, the community-owned PaaS can provide valuable platform services of local interest, with tighter integration with the local environment. This setup, built on community-managed platforms can, for example, deliver activity logs that enable higher levels of transparency and auditability of cloud applications. A practical application is in the IoT domain, where a publish-subscribe platform service can be audited in terms of data input and output, thus providing more local control about personal data flows (such as running cloud applications in community or home locations, firewalled from the open Internet, and monitoring or auditing data transfers for trust and privacy reasons). The experimental guifi.net CC is another case detailed in [13].

6.2.2 Stakeholders

Our experience over two years working with the guifi.net community and its community cloud deployment confirms a similar stakeholder structure of the guifi.net network commons. The coexistence of volunteers and for-profit participants, already happening at the network level, has started to expand to all cloud layers, with initiatives, experiments, or offers at all cloud levels, but not to a significant scale yet. In a comparable way, the presence of a minimum number of customers (and the corresponding service providers) is crucial to ensure the required income to sustain the system. The participation of public administrations is also desirable but is not there yet. Nevertheless, the *proactive* motivations (*we participate because we want to, either to self-satisfy our cloud needs or to contribute to the initiative*) must be explicitly promoted because, at the cloud level, public administrations have much less legal obligations to intervene than at the network infrastructure level. Ideas such as the digital exchanges mentioned above, create opportunities and incentives for local partnerships among all stakeholders in creating local data centres to host computing and service infrastructure and to promote local public and private services, socio-economic development, and digital inclusion.

One topic in the discussion between the research team and members of the community involved in the pilot was about the inter-dependency between the different cloud components that can lead to a separation between volunteer and professional initiatives given the quality of service expectations, unless the software can provide effective quality control (e.g., isolation, prioritization, interference, and congestion control), and a socio-economic mechanism exists to quantify and compensate the contribution and consumption of resources and services among all participants. However, this is still under research, regarding examining virtualization [13], incentives [16], activity logs, and payments ledgers using blockchains or digital currencies [21].

During the pilot, the central role of software development was clear to all. The CCs require an international community of open-source software developers (voluntary or professional but not necessarily local) that develop and maintain a set of core tools, APIs, and compatible applications that can be shared by many CCs. The software, far from trivial, requires not only initial developments but also adaptation of cloud software intended for other scenarios (e.g., data centre), integration, and maintenance.

Finally, working with the community of users, the need for a reference authority was clear, similar to Guifi.net Foundation in the case of the network, as proposed by the guifi.net community. This role was assumed experimentally by the Guifi.net Foundation. This allows us to bypass the overheads of creating a new organization, but in the future, if the project consolidates into a stable CC, a dedicated organization is imperative to preserve the independence of the two ecosystems.[5]

[5] Guifi.net Foundation has actively participated in the whole conceptualization process as well as the development of the software stack and in the implementation of the experiments.

6.2.3 Participation Framework

As a result of the pilot, and the discussion with the guifi.net community, we propose a separation of the body of normative structure into layers with a general mandatory licence and a set of complementary dedicated agreements. The details of the structure can vary for other CC, but the principles will be equivalent.

Licence A CC commons licence (CCCL), which harmonises the contribution and usage of the cloud resources, eases the take-up process of the CC model in a similar way as the network licence has had on the network infrastructure. The discussions about CCCL have started, but the licence has not been established yet. Similar to the network commons license process, the steps to draft the CCCL licence go through deliberation with the community and evolve as the commons develops and transforms. The discussion with the community, with a rights-based approach [22], has resulted in the following proposals. The licence must consider aspects like the relationships between users and service providers and between the cloud layer and network layer. We propose that the licence must cover at least the following aspects:

Neutrality The requirement of public access without discrimination, that is, providing the same treatment (service) unless there is some compelling reason.

Fair usage Rules of conduct and means of control to avoid abuse of the resources in commons.

Transparency and accountability As discussed, access to information and accountability is essential in any CPR and is an enabler for participation in the operation and governance of the commons.

Privacy In an architecture where sensitive data are distributed across the network, privacy respect and protection must start from the licence. This implies precautions to handle private data, which may be collected deliberately or not, with proportional care, according to data protection laws and security standards.

Collaboration agreements As with the network infrastructure, the level of commitment of the operators with the commons is expressed through a supplementary agreement detailing the specific implications of the licence, considering service-level objectives (SLO). The set of collaboration agreements for the cloud contributes to enhancing confidence among operators offering cloud services, comparable to our experience with the network infrastructure commons.

6.2.4 Socio-economic Tools

As in other communities, the governance involves all actors to drive a CC infrastructure through challenges and changes to keep it operational and balanced, which is key to resilient and adaptive CPRs. From the discussion with the guifi.net community, the following tools were proposed as necessary, although they must be adapted to local conditions:

Conflict resolution system In the case of guifi.net, the already existing system for the resolution of conflicts can be applied 'as is' to CC related issues.

Sanctioning system The general structure as well as the administrative provisions of the guifi.net sanctioning system is a good starting point. The technical provisions must be tailored to the specific requirements of CC.

Economic compensation system It must clarify the terms of participation to promote investment and reduce the number of disputes. The already existing network compensation system (see [23]) can be adapted to fit the cloud requirements and can be used to balance expenditure at the cloud layer. In addition, the effect that the usage of the cloud services can have on the network infrastructure and its consequences on the economic compensation system of the network must be investigated to determine whether the current calculation system, which is based on the total amount of network traffic at the points of presence of the infrastructure, suffices or needs to be adjusted. This system must balance the exchanges

of disparate resources (IaaS, PaaS, and SaaS) between the different participants (volunteers, coops, and for-profit enterprises).

6.2.5 Communication and Coordination Tools

As with the network infrastructure, the diversity in the requirements for the coordination of the collaboration can only be covered through the combination of several tools. The discussion with the guifi.net community raised the need for the following tools:

Software tools for cloud management and provisioning The guifi.net website success shows that efficient and easy-to-use solutions for participant needs are key for the project uptake and harmonisation of the participation. As for the CC, most of the needs can be grouped per cloud layer as follows: for IaaS, contribution and request for computing and storage capacity; for PaaS, deployment and discovery of services, user authentication, and access policy management; and for SaaS, an initial set of appealing applications.

Communication tools From the experience during the pilot, tools (mailing lists, web fora, etc.) and strategies (face-to-face meetings, presentations, etc.) were indispensable. In an equivalent way, the provisioning and management of the infrastructure and services can benefit from specific solutions and separate communication channels.

6.2.6 Initial Key Enablers

Our experience shows that the start-up phase of any community initiative is critical, including our action and experimentally driven research. From the initial discussion with the group of volunteers to prepare the launch of the pilot and from the ongoing discussions and experience with the guifi.net community during the pilot, these are our collective findings on the key conditions (feasibility factors) that must be met to ensure a successful bootstrap of a CC:

Demand As a result of an increasing global awareness on data privacy, security concerns, etc., there is a growing demand worldwide for user-driven (self-provided) cloud services. We confirmed during the pilot that this demand also exists within that community. We collected requirements and suggestions from the participants, which determined the priorities in the implementation of the service offering.

Early adopters The start-up phase is critical for any cooperative project. Among the guifi.net members, there is a respectable number of technology enthusiasts interested in experimenting with innovations. Moreover, the authors have been involved in guifi.net for more than a decade, which facilitates the introduction of the product. The involvement of a few key active and recognised adopters in the start-up phase accelerated the involvement of the rest of the community in the pilot.

Third-party technology availability The two main requirements are network connectivity and computing and storage capacity. Affordable off-the-shelf devices powerful enough to run our cloud software stack have been available in the market for more than half a decade. Thus, a CC can be bootstrapped anywhere with local or Internet connectivity. In terms of software, the existence of many open-source base components (e.g., GNU/Linux, services, and applications) were enablers for the start-up phase.

Ease of participation As explained earlier, our working hypothesis is that CCs can emerge through a comprehensive cloud software stack that meets local needs. Such software solutions did not exist yet before our work. Although the early adopters in our pilot were not hindered by a more complex system, ease of participation resulting from the ease of use of the CC software was their main concern, and the usability of the user interface became a central aspect.

Cloud licence In view of the positive effects of the guifi.net NCL (e.g., CPR protection, encouragement of investment, and dispute avoidance) and given that the introduction of major changes becomes more

difficult in larger communities, the precise definition and approval of the *CCCL* is the main next step to ensure the sustainability of a larger community beyond the pilot.

6.3 The internal model

Based on the model defined, the CPR CC internal model is depicted in Fig. 6.3.

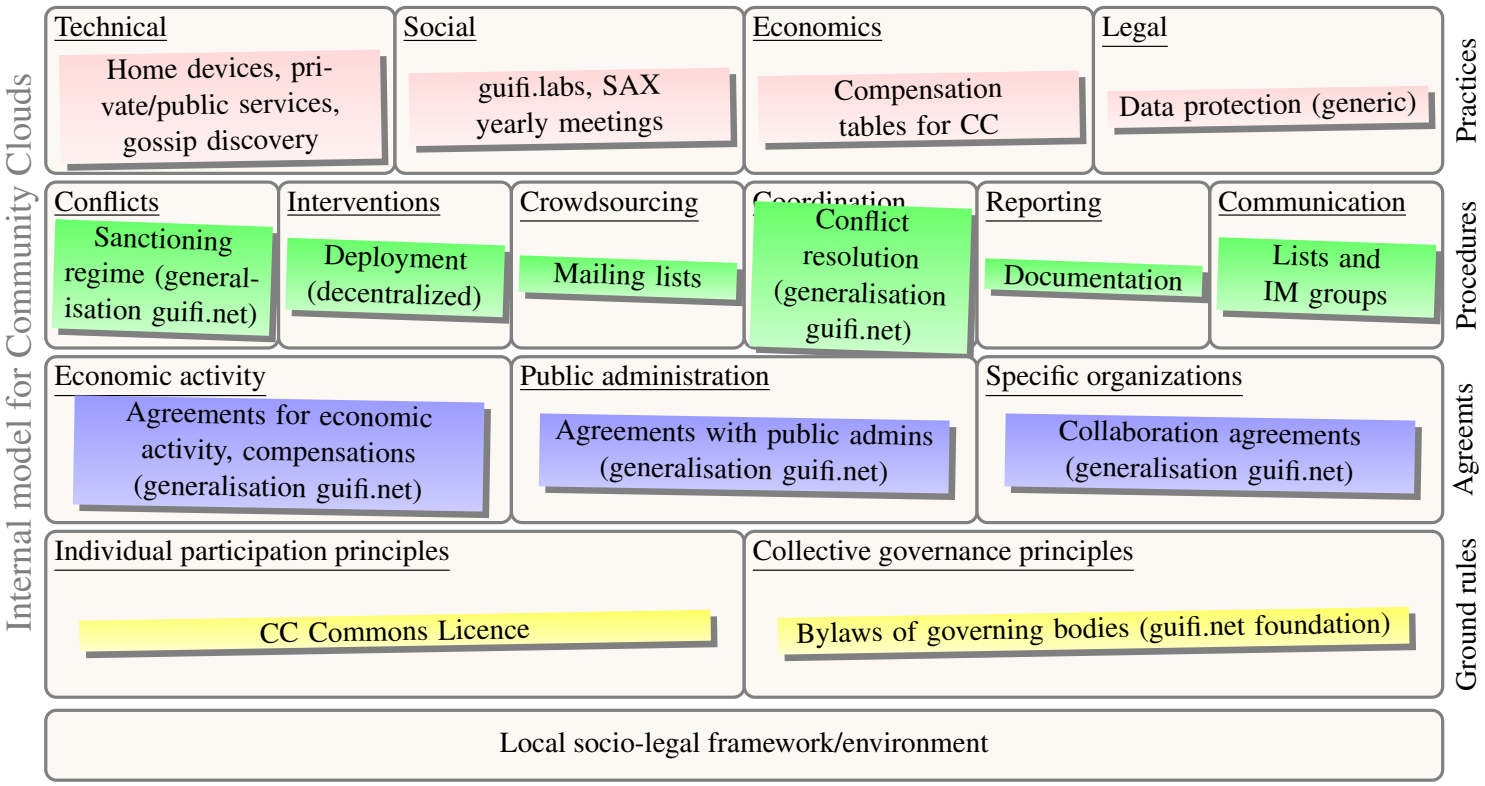

Figure 6.3: The outline of the internal view of the CC CPR in guifi.net

6.4 Discussion

In previous sections, we elaborated on key aspects of the governance and implementation of CCs. Here we discuss several reflections about factors and artefacts that appeared during the collaboration and discussions, as part of the action research, with the guifi.net community and their participants directly involved, with respect to the nature of CCs as CPR. We first describe the idea and its relevance, and then we discuss the analysis and lessons learned.

Despite the lack of benefits from economies of scale in unit costs compared to large remote cloud data centres, local infrastructures have their own technological advantages in terms of latency, better connectivity with end users, partition tolerance, or faster and more regular transfer rates, in addition to advantages in privacy and data sovereignty of own data. As a result of local cooperation and sharing, users enjoy cheaper or even free local network traffic, cheaper local cloud infrastructure, and socio-economic advantages from local interactions, investing and contributing to the local economy and promoting local development. The most relevant factors that emerged during the pilot are detailed next.

Participation with contributions Users must be willing to participate with contributions to the CC. These contributions can be in terms of hardware, locations, maintenance, etc. The entry cost is relatively small:

a low-capacity and low-power device[6] is enough to start. The installation process is relatively simple, and the devices require little maintenance. These tasks can even be delegated to a friend or trusted member of the community. A large body of research and practical experience in the past has already shown that users are often willing to donate spare computing resources to third-party propositions in exchange for added value [24]. Economic or social incentive mechanisms building on that have been proposed in CCs [25] and CNs [16] research.

Access to nearby strategic locations (e.g., homes, service rooms in buildings, street cabinets, warehouses, and public data centres) is another beneficial factor from CPR clouds. Many key local public and private stakeholders can offer these locations to voluntary and commercial service providers for the local interest. The locations of the resources are valuable assets for enabling innovative locality-critical services without relying on Internet connectivity. In addition, privacy regulations and privacy protection can be more easily fulfilled if a commercial service runs on local CPR-provided cloud infrastructures due to lower costs and more opportunities to audit and control the collection of personal data. Such an approach has enormous potential to address use cases in the smart-city and IoT domains.

Locality and cooperative cost sharing Therefore, there is a local opportunity to beat or complement traditional Internet cloud infrastructure and service providers in terms of pricing or features that stem from locality and the cooperative model of cost sharing in CNs [23], taking advantage of the shared collective network and cloud infrastructure. In such a model, local entrepreneurs can venture in setting up garage or warehouse data centres, or established organizations, like companies, governments, schools, farms, or factories, can lower their costs by venturing into the IaaS business for local cloud users.

Cost-oriented pricing for local sustainability From a business perspective, CCs offer resources and basic services according to a cooperative commons model with a cost-oriented pricing. The costs should include fair remuneration and local reinvestment to preserve the sustainability of the commons. For SMEs and entrepreneurs, the CPR is a suitable context for experimentation and learning and an opportunity to explore commercial services without a strong initial risk or capital investment. Research about cost sharing in CNs [23] explores this factor.

Voluntary and professional effort In the commons, we find coexistence and cooperation between voluntary and professional schemes. The first usually comes with no service commitment (best effort or less), while the second involves specific commitments (Service-level Objective (SLO)) in exchange for service fees. Ideally, both schemes can complement each other. Volunteers can buy and include professionally maintained resources in their voluntary efforts, and professionals can occasionally leverage from voluntary resources or efforts in their services (e.g., software tools and peer-assisted cloud services) in exchange for contributions back to the commons. This close collaboration allows pooling and growth at smaller steps with smaller upfront costs. A file and backup service, for instance, can be deployed on a hybrid schema combining a stable server infrastructure with less stable resources from volunteers to handle peaks or growth at the expense of a compensation fee. Local currencies have been explored [21] to regulate these transfers without involving fiat money.

Influence of underlying conditions Community clouds can, in principle, develop over any kind of network infrastructure. While the commoditisation of hardware (low cost), software (free and open), networking (flat rates), and access to locations (facilities for deployment and right of pass) is a major enabling factor for sharing, the major barriers come from differentiation, such as with traffic-based (instead of capacity-based) charging or lack of traffic neutrality (when ISPs do traffic discrimination by throttling or blocking local servers and promote paid fast lanes for major Internet cloud and content providers), or provide asymmetric access (a TV-like Internet).

Scalability Local community commons can also benefit from economies of scale through the local aggregation of resources (e.g., pooling of needs for data stores, remote backups, server consolidation for public websites, databases, hosts, and containers). This way, a group of small and medium local cloud users

[6] e.g., mini-computers or single-board computers, such as the Raspberry Pi or a NUC device.

can act as wholesale intermediaries and benefit from volume pricing from large Internet cloud providers. This requires interoperability and federation mechanisms to group resource needs and to transparently integrate Internet cloud providers as a backend. The wholesale access to Internet carriers or Voice over IP providers by ISPs involved in the guifi.net CN or the digital exchanges discussed in Section 6.2.1 are good real examples of that.

Second-layer organizations A cloud commons can act together as a larger organizational umbrella representing and protecting their collective interests in the face of external agents, like governments, companies, users, regulators, research organizations, investors, and standardisation bodies. Guifi.net Foundation, which has played that role for the CN, sees similar challenges for CCs, and an umbrella organization can represent and more effectively protect a group of emerging local CCs better than CCs can individually.

Validation of the CC model Regarding the validation of the CC commons model, our experience with the guifi.net CC shows the value of the scenario of 'platform commons' (scenario *c* in Figure 6.2) but also its difficulties. We managed to work with different stakeholders, for example, many volunteers and two professionals interested in the feasibility and sustainability analysis of the file storage service. We worked with software developers. Some were supported by research projects, and others as volunteers, and we counted on the support of Guifi.net Foundation. In the context of the participation framework, we started the dialogues for the CCCL and the compensation system, and although such social processes of deliberation take time to deliver results, the interim results are positive. Therefore, we can conclude we have developed a functional organizational and governance model for a CC infrastructure as an open commons (CPR). Applied to other different environments may require adaptation.

6.5 Summary

Community clouds (CCs) at the network edge are motivated by their disruptive potential for changing the future cloud service landscape by expanding the current cloud service offerings with local cloud resources and service infrastructures open for access (usage) and open for participation (construction, operation, and governance). This chapter presents an analysis, design, and evaluation of the artefacts and enabling factors for the feasibility and sustainability of local CCs, through the development of an organizational and governance model. To this end, we discuss specific issues for the applicability of these mechanisms in CC-based services are discussed. The model we propose, inspired by the experience of guifi.net but applicable to other communities, implements a CC with the IaaS and PaaS layers organised as an open CPR. A framework of tools (artefacts) to govern such a CC is presented. Some of these components have been already implemented in the Cloudy software stack.

The total number of Cloudy devices, deployed during the second half of 2015 until now that we are aware of, is 62, and the average number of online cloud nodes at the end of 2016 (50) was around 80%.

Future experimentation and piloting of CCs with the Cloudy software will help to extend the model and system to other services, evaluate replication in other regions, other socio-economic environments, other CNs, and on a larger scale. It is interesting to note that CCs as open commons, despite being inspired by CNs, can develop in diverse environments, including Internet access networks provided by commercial ISPs.

7 Conclusions

This report analyzed the impact of organizational changes (re-engineering) in the governance of specific community networks (CNs). We worked with each CN interested to incorporate such governance tools and promote certain organizational patterns or mitigate certain anti-patterns, always adapted to the characteristics of each. Improvements and restructuring can have different degrees of impact in the outside or inside view of a CN, and different time scales for implementation. We have provided an analysis of the re-engineering processes, with the definition of metrics to monitor the output (application of instruments) in terms of improved resilience, scalability and sustainability.

In the analysis of external and internal models we have witnessed that while some CNs tend to be clubs of like minded people providing alternative local Internet governance models, other CNs focus on the mission of delivering a solution to address the needs of all the under-served population in a region. This is also visible as networks scale up, depending if the model relies purely on voluntary work, or if, as the network grows, volunteers professionalize, and CNs can not only produce connectivity, but can also create jobs, and surpluses to be reinvested in improved connectivity, network expansion, local credit, and local socio-economic development.

We have built long lasting relationships with many CNs. This has served to motivate and launch an ongoing and natural process of organizational evolution, based on trust and mutual learning, not only with netCommons researchers, as we have also contributed to strengthen a "social network" across CNs themselves and researchers and practitioners that spin around CNs, facilitated by meetings and workshops organized by netCommons and other global related organizations.

Beyond the ongoing re-engineering processes, the exercise has helped CNs to raise awareness and understand better their own organizational structures in comparison to others. This helps CNs to understand better the resulting limitations and opportunities, under a common framework that allows for the comparison of structures and patterns with respect to other CNs, in similar or different environmental conditions. However, CNs take time to evolve since their own nature based on collective organizational learning, experimentation and decision making. We firmly believe that the ongoing activities, supported by other partner organizations, provide a guarantee that the launched processes of organizational re-engineering will continue and even accelerate. We see these interactions has fed wider discussions and exchanges across CNs themselves, creating even more opportunities for further organizational evolution.

In summary, our analysis, feedback and support regarding organizational and governance models in WP1, has not only increased the understanding and produced a portfolio of internal and external models and patterns, but also it has contributed to evolve the internal governance structures of many CNs towards increased resilience, sustainability, and better local impact through the external organizational model. In turn, these local impacts are not just about widespread connectivity that translate into enabling and improving social inclusion and participation, but also these result in improvements of social welfare and the creation of resources for local socio-economic development.

7.1 Contribution to netCommons goals

The work carried out in Task 1.2 contributed to achieve netCommons goals in several ways.

- In general, CNs face many challenges and they also need abstractions, models and practical tools to grow and produce a higher beneficial impact on our society. In this Deliverable work, based on the work of WP1 (specifically T1.2), but also on inputs from other WPs, based on the portfolio of organizational models developed (T1.1), we have analyzed, provided feedback, and supported several CNs in their

processes to evolve their internal governance structures to improve their governance and adaptability to become more effective and efficient in their goals, and achieve more organizational resilience and sustainable growth (Objective 1.2 of netCommons).

- In particular, the organizational models of several CNs have been analyzed in detail, presented in summarized form (external and internal models), mapped in relationship to the organizational patters defined in D1.3, and then supported in their processes of organizational development and change towards maturity.

7.2 Impact of the work

Besides contributing to achieve the scientific an societal goals of netCommons, Task 1.2 has and will have a direct impact on CNs as well as on the understanding of networking infrastructure commons and the application to organizational improvement.

In terms of the *Collective Awareness Platforms for Sustainability and Social Innovation (CAPS)* work programme, we have:

- Pioneered the maturing of promising models of participatory innovation. We have worked with CNs to understand and improve the effective involvement of citizens and other actors, in the establishment of durable interdisciplinary collaborations in the development of sustainable and participatory local connectivity for local socio-economic development.
- We have defined new concepts and models for the development of digital social platforms related to local connectivity, as well as helping them to optimize their applicability to societal challenges.
- In the scientific domain, we provide evidence based understanding of the techno-social issues related to the domain of connectivity and digital inclusion.
- Our results contribute to achieving in the longer term the active citizen participation in decision making, collective governance (including global Internet governance), new democracy models, self-regulation, new business and economic models.
- We have worked with different key stakeholders (citizens, researchers, public authorities, private companies, non-profit, non-governmental and any other civil society organisations) and contributed to create measurable improvements in the cooperation among them in the development of new sustainable and collaborative connectivity.

In terms of the impacts defined in netCommons, the definition, development, comparison and improvement of organizational models has delivered the following impacts:

- Local Impact 1: (Governance guidelines for CNs) with specific impacts:
  1. Improve the internal governance of communities synthesizing organizational models, get better decision making processes;
  2. Increase their touch (on values, awareness, acting) on the external society, through improvement of external organizational models.
- Local Impact 2: (Sustainable growth of CNs) with the specific impact:
  1. Help communities to formalize their political and social goals;
- Global Impact 1: (Alternative Internets Made Possible) through the adaptability and sustainability that bring organizational development and maturity to CNs.

These impacts are not only attested by the interactions and organizational evolution processes involving several CNs involved, but also globally through interaction with other CNs and global actors, such as United Nations in the IGF, IEEE, ISOC, APC, among others.

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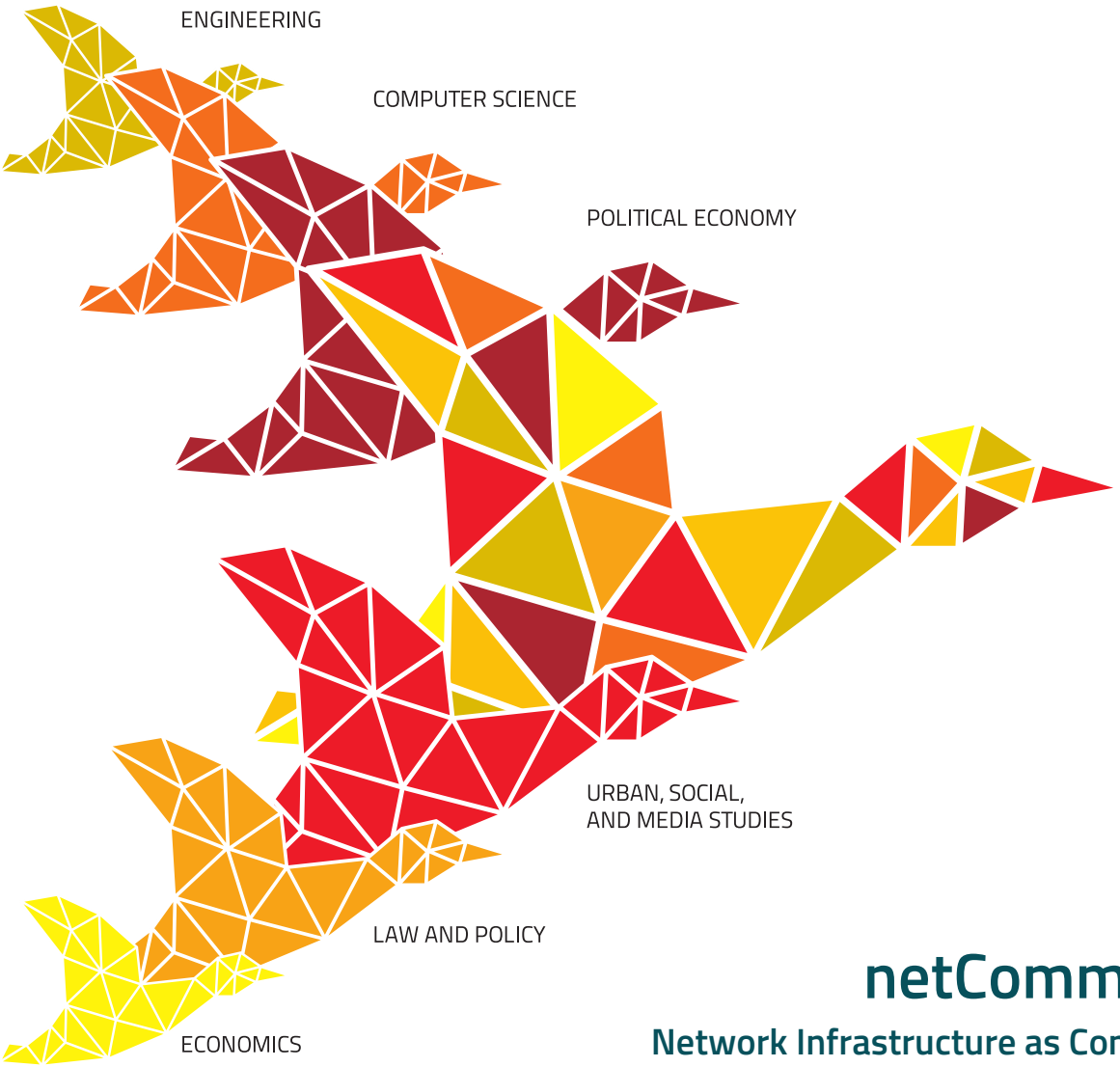

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Report on the Governance Instruments and their Application to CNs (v2)

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