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OVERCOMING RESOURCE CHALLENGES IN PEER-PRODUCTION COMMUNITIES THROUGH BRICOLAGE: THE CASE OF HOMENETS

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Abstract

Peer-production communities can create great value and foster innovation for their members, even in situations where resources are extremely scarce. How these communities create or acquire necessary resources in such settings is an important theoretical and practical question. In this paper, I investigate how a peer-production community overcame substantial resource challenges, using the analytic lens of bricolage theory, in a longitudinal study of HomeNets, communities of residents that developed residential Internet infrastructures and services for a million users in Minsk, Belarus, without funds, material resources, knowledge, or formal legal status. The findings illustrate that communities develop their missing resources by engaging in multiple coexisting bricolage forms and processes, which help them to successfully incorporate the individual and collective resource building efforts of their participants and address the challenges specific to the continuously evolving community. Based on the findings, I propose a model of community resource development with bricolage, discuss theoretical and practical implications for studies on communities and bricolage, and suggest areas for further research.

Key words: peer-production communities, resources, bricolage, information technology, case study

1. Introduction

Peer-production communities (*communities* hereafter) are new forms of IT-enabled collectives that produce innovative and valuable products and services (Barrett et al., 2016; Benkler, 2017; Faraj et al., 2016; Puranam et al., 2014; von Krogh et al., 2012). Communities create high-quality goods and services that can compete with those created by traditional organizations. Prominent examples include the world's largest online encyclopaedia, Wikipedia; popular open-source (OC) operational systems and applications (Linux, OpenOffice, Firefox browser, VCL media player, and Moodle); and a free online map of the world (OpenStreetMap, with 7.5 million users). These communities begin as grass-roots efforts or as underfunded entrepreneurial ventures with few resources readily at hand, yet they manage to be innovative forces. How these communities manage to do so is an important theoretical and practical question.

Organizational environments are characterized by the fact that they are unpredictable, constantly changing, and associated with resource scarcity (Brown & Eisenhardt, 1997; Cunha et al., 2014; Tsoukas & Chia, 2002). Baker and Nelson (2005, p. 353) define such environments as penurious, that is, presenting "new challenges, whether opportunities or problems, without providing new resources" and call for research into how such organizations create missing resources. In this regard, communities demonstrate the ability to mobilize missing resources and develop inclusive and affordable innovations in resource-scarce and crisis situations; recent examples include innovations to combat natural disasters (Williams & Shepherd, 2021) and the COVID-19 pandemic (Armani et al., 2020; Frazer et al., 2020; Majchrzak & Shepherd, 2021; Richterich, 2020). The focus of this research is the development of community-based Internet infrastructures in areas considered unprofitable by Internet providers (Powell & Meinrath, 2008; van Oost et al., 2009).

This paper applies the theory of bricolage—"making do by applying combinations of the resources at hand to new problems and opportunities" (Baker & Nelson, 2005, p. 333)—as an analytical lens for understanding how communities develop missing resources. Bricolage theory has been applied in a variety of traditional organizations, including entrepreneurial ventures, corporations, and institutions (e.g., Baker & Nelson, 2005; Ciborra, 2000; MacKay & Chia, 2013; Mair & Marti, 2009), but to date there have been few insights into how emerging forms of organizing, such as peer-production communities, develop their resources with the use of bricolage.

This paper studies HomeNets, communities that developed residential Internet infrastructures and services in Minsk, Belarus, from 1994 to 2016. Created in the mid-1990s by small groups of residents to play multiparty games and share files in the absence of affordable Internet access from Internet service providers (ISPs), HomeNets grew in the first decade of the 2000s to become the country's largest online communities (OCs) and residential Internet infrastructures, serving a million people (out of the country's 9,5 mln population). After a 2010 law limiting home-based Internet services, some communities transformed into successful HomeNet ISPs. The longitudinal nature of the case allowed the variety of resource challenges and opportunities that HomeNets addressed to be followed.

My findings indicate that communities successfully develop their missing resources by engaging in multiple, co-existing, and evolving combinations of forms of bricolage. Based on these findings, I develop a model of community resource development with bricolage. The model illustrates specific combinations of individual and collective bricolage forms and related bricolage processes that enable communities to develop their missing resources according to their evolution phases and the nature of experienced challenges. The findings support and,

importantly, extend previous studies that suggested a link between community organizational characteristics and the ability to attract and develop resources (Faraj et al., 2011; Puranam et al., 2014; Raymond, 1999; von Krogh et al., 2012). In particular, this study is among the first to link community organizational characteristics to particular forms and processes of resource development. It illustrates how engagement in bricolage helps communities to develop diverse resources, and it provides a possible explanation of their success in resource-scarce and crisis situations (Majchrzak & Shepherd, 2021; Williams & Shepherd, 2021). Further, in contrast to traditional organizations, where access to bricolage is selective (e.g., Duymedjian & Rüling, 2010), and engagement in simultaneous multiple bricolage processes impedes organizational growth (Baker & Nelson, 2005), the findings illustrate that communities can profit from engaging with multiple coexisting bricolage forms and processes.

2. Background literature

2.1. Communities as resource development sites

Communities can develop resources[1] that might significantly exceed those of organizations (e.g., Benkler, 2017; Puranam et al., 2014; Raymond, 1999) and can develop inclusive innovations in environments with missing and limited resources (Armani et al., 2020; Majchrzak & Shepherd, 2021; van Oost et al., 2009; Williams & Shepherd, 2021). The ability of communities to develop resources of unprecedented scope and scale has been attributed to their distinctive organizational characteristics, which enable decentralized cooperation, intrinsic motivations, and fluidity (e.g., Benkler, 2017; Faraj et al., 2016; Faraj et al., 2011; von Krogh & von Hippel, 2006; Raymond, 1999). For example, Benkler (2017, p. 264) argues that "[p]eer production is the most

[1] Defined as "all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness" (Barney, 1991, p. 101).

theoretically radical organizational innovation" that enables the decentralized cooperation of intrinsically motivated actors with highly diverse knowledge to successfully operate complex projects in uncertain environments (Benkler, 2017). Similarly, Faraj et al. (2011) attribute the ability to engender a dynamic flow of resources in and out of the community to the fluidity of community boundaries, norms, and participants. In this regard, Puranam et al. (2014) specify that communities solve the four classic organizational problems—task division, task allocation, reward provision, and information provision—in new ways. I summarize the distinctive community characteristics as posited by Puranam et al. (2014) in Table 1 and discuss their impact on resource development within communities.

--- Insert Table 1 here ---

First, unlike traditional organizations, where *task division* (mapping the goals of the organization into tasks and sub-tasks) is centralized through formal authority and rules, task division in communities is decentralized and is executed through leadership and informal authority (Benkler et al., 2015). While community leaders formulate the key tasks to be addressed (such as in Linux and Bitcoin communities), other participants can engage in task division, such as when "somebody finds the problem [and] somebody else understands it" (Raymond, 1999). This enables flexible ways of matching organizational goals and problems with possible resources for their solutions; it also allows for alternative options in defining what resources to explore and use, since community participants follow their own initiatives, interests, and idiosyncratic visions (see Table 1). For example, members from the periphery of the community social structure often explore innovative ideas ignored by core members (Dahlander & Frederiksen, 2012). Likewise, Stanko (2016) discusses community remixing, i.e., using existing innovations as source material to aid in the development of further innovations. In addition, communities provide risk-free settings that are highly tolerant of experimentation and

creative behaviour on the part of members, which increases resource variety and remixing.

Second, in contrast to traditional firms, where *task allocation* (mapping the tasks obtained through task division to individual agents and groups of agents) relies on formal roles and workers' specialized qualifications, community participants self-select roles and contributions (Benkler et al., 2015; Haefliger et al., 2011; von Krogh et al., 2012; Wasko & Faraj, 2005). Self-selection of tasks harnesses the involvement of talented, motivated individuals (Benkler, 2017). It also increases the pool of available resources since multiple members self-select and take care of the same task, which increases the creative use of resources (Benkler, 2002; Zittrain, 2008) (see Table 1). At the same time, self-selected involvement leads to fluctuations in the resources that participants bring with them and challenges of task coordination and planning since many participants might be invisible for substantial periods of time, or may contribute in a form of peripheral participation (Faraj et al., 2011; Faraj et al., 2016). Decentralized task allocation can also lead to duplication and misinformation (Puranam et al., 2014), requiring additional resources for detecting and correcting these; this is common, for example, with Wikipedia.

Third, the *motivations and rewards* of community participants are prevailingly intrinsic and non-monetary (Benkler et al., 2015; Haefliger et al., 2011; von Krogh et al., 2012; Wasko & Faraj, 2005). While this community characteristic often leads to impressive member commitment and increased creativity, it can also lead to fluctuations in participation and, as a result, fluctuations in the resources available to the community (Benkler et al., 2015). For example, Faraj et al. (2011) discuss passion as an important motivator for contribution to the community. However, participants with different passions can alienate themselves and exit the community, or they can lose interest. Another challenge is the "free-rider" problem: the possibility for anyone to benefit regardless of their contribution level (Puranam et al., 2014). Communities successfully

solve this problem by developing norms and ensuring that the intrinsic rewards for at least certain members remain high, regardless of whether or not others contribute (Raymond, 1999).

Finally, the *provision of information* (i.e., providing organizational members with the information needed to execute tasks and coordinate their actions) allows communities to coordinate resource development. In contrast to organizations, where physical collocation and centralized task division and allocation reduce the need for information provision and coordination with special tools, communities rely strongly on IT to enable communication and the coordination of efforts. In this regard, IT creates a necessary "dynamic virtual space" (Faraj et al., 2011, p. 1226) for communities to function in the absence of formal authority, employment contracts, and property rights (Benkler, 2017; von Hippel & von Krogh, 2003). Specifically, IT tools make visible what is created by the participants through electronic communication, platforms, visualization of joint tasks and the entire work system, detailed comments in and documentation on the source code, and the displaying of participant statuses (Benkler, 2002; Faraj et al., 2016, Puranam et al., 2014). This implies that the community's ability to develop and use resources is highly dependent on IT tools for visualizing what resources are available and how these are used, and for coordinating members' development and use of resources.

2.2. Theorizing community resource creation with bricolage

2.2.1. Resources and bricolage

Bricolage theory aims to explain how organizations create value with the resources at hand (Baker, 2007; Lévi-Strauss, 1966). Bricolage is often used by organizations operating in resource-scarce or fast-changing environments (Baker & Nelson, 2005; Mair & Marti, 2009; Perkmann & Spicer, 2014), as well as by those operating in crisis situations (Duymedjian & Rüling, 2010; Weick, 1993). Bricoleurs (those who engage in bricolage) reject the imposed

limitations defined by institutional and cultural settings by using available resources considered by others to be useless or dormant, thus overcoming the apparent scarcity of resources (Baker & Nelson, 2005; Garud & Karnøe, 2003; Lévi-Strauss, 1966; Penrose, 1959). Deploying resources at hand helps actors in crisis to develop resilience by engaging in the processes of trial and error and maintaining their capacity to act, rather than being paralyzed (Duymedjian & Rüling, 2010; Weick, 1993).

The breadth of resources that might be used for bricolage is wide. Thus, bricolage can entail both "(a) using second hand materials to build an artefact or a structure when nothing more appropriate is available [and] (b) using old components and structures to perform new functions, putting them to a different use from the one they had been originally designed for" (Lanzara 1998, p. 27).

Bricoleurs can outperform those with abundant resources (Baker & Nelson, 2005; Engel et al., 2017; Garud & Karnøe, 2003; Illia & Zamparini, 2016). In particular, (re)using available material resources at hand enables organizations to create missing physical assets (Baker et al., 2003; Garud & Karnøe, 2003). Recombining existing elements of organizational structure into new ones enables organizations to successfully overcome challenges and create opportunities in fast-changing environments (Ciborra, 1996; Lanzara, 1998; Mair & Marti, 2009; Perkmann & Spicer, 2014). Network bricolage (reliance on pre-existing contact networks as a means at hand) helps actors acquire capital, physical assets, knowledge and information resources (Baker et al., 2003; Engel et al., 2017) and enables those with little power to access support from participants with differing interests (Mair & Marti, 2009). In a similar way, identity and institutional bricolage helps actors define who they are by recombining stories about their collective selves with locally valuable cultural, social, and political narratives, thus granting them higher

legitimacy (Illia & Zamparini, 2016; Mair & Marti, 2009).

IT resources—specifically, the adaptation and reassembling of available IT—have been discussed as being particularly suitable for IT bricolage (Duymedjian & Rüling, 2010; Faulkner & Runde, 2009), often in the form of "serendipitous combinations of existing programs, pasted-up solutions, and failed components put to unexpected uses" (Baker & Nelson, 2005. p. 335). As Duymedjian and Rüling (2010) state, "characterized by a high degree of flexibility in use … [i]nformation systems are rarely used in the ways for which they were originally conceived—diversion of functions, breaking up and recombination of systems in use are signs of bricolage" (pp. 135–136) This enables an "infinite collage" (Duymedjian & Rüling, 2010, p. 136) of possible reuses and alternative enactments from a great variety of users, both experts and amateurs (Ciborra, 1992; Garud et al., 2008; Faulkner & Runde, 2013; Zittrain, 2008). Likewise, Zittrain (2008) discusses how, lacking the vast resources needed to implement a global architecture, Internet creators "made the network work" (p. 1985) by designing its key innovations (stateless protocol, packet switching, and routing) as a highly flexible, decentralized network allowing end-to-end additions that neither taxed a central hub nor required centrally managed adjustments to overall network topography. Non-material IT objects are also highly reproducible because of their very low marginal cost (Faulkner & Runde, 2009). For example, Garud and Karnøe (2003) illustrate how small firms can outperform large corporations by interacting with the local actors at hand and then recombining the acquired local knowledge into "higher degrees of functionality" (p. 296).

2.2.2. Developing resources with bricolage

Engaging in bricolage starts with the creation of a *bricolage repertoire*, a stock of heterogeneous material and immaterial resources collected with no clear intention before the act of bricolage

(Duymedjian & Rüling, 2010; Lévi-Strauss, 1966). Confronted with a particular need, the bricoleur (re)considers the value of resources and their associations and reassembles these into a "new arrangement of elements" (Duymedjian & Rüling, 2010, p. 137), which is applied to answer the need but might later be de-assembled into a new repertoire for new purposes. The above process of resource development with bricolage can proceed in different ways in organizational contexts. Specifically, Duymedjian and Rüling (2010) distinguish three forms of bricolage repertoire creation by organizational actors. Table 2 provides details on each form, its actors, and its key features.

--- Insert Table 2 here ---

As Table 2 illustrates, small organizations, such as individual and family enterprises, or relatively small groups within big organizations (e.g., schools, corporations) can engage in *individual* bricolage. This is characterized by an actor's close familiarity with resource repertoire and a highly coherent vision of what constitutes important resources and how to use these to address new problems and respond to opportunities. The original founding work on bricolage by Lévi-Strauss (1966) provides examples of individual bricolage by an aboriginal person and a modern engineer, both of whom are familiar with the nuances of their resources and their contexts, and who apply the resources at hand to address new problems and respond to opportunities.

In contrast, in large organizations and collectives, where different people have different visions and assumptions about what constitutes valuable resources and how these might be assembled, *collective* bricolage repertoire takes place. Collective bricolage links multiple resource stocks (Duymedjian & Rüling, 2010) and comprises a larger variability of resources, including materials (Baker & Nelson, 2005; Garud & Karnøe, 2003); symbolic, cultural, and

structural resources (Lanzara 1999; Mair & Marti, 2009); and socio-cognitive resources, such as organizational memory, collective specialist knowledge, pre-planned protocols, role systems, and cross-member expertise (Bechky & Okhuysen, 2011; Faraj & Xiao, 2006; Klein et al., 2006). In this regard, Duymedjian and Rüling (2010) distinguish two forms of collective bricolage. *Convention-based* collective bricolage relies on the sum of multiple individual repertoires of organizational members. Access to resources constituted by the sum of individual bricolage repertoires is enabled by conventions negotiated between the actors, such as norms, standards, measures, and terminology. In contrast, *familiar-based* collective bricolage develops when organizational members share time/space and co-presence in repertoire creation and use. Informal interactions, access to each other's tacit knowledge and know-how, and trustworthy and close relationships also enable a collective familiarity with resources to develop. The development of familiar-based collective bricolage is thus not obvious in every organization.

2.2.3. Theorizing bricolage processes within communities

Research discusses successful community innovations in resource-scarce environments (Frazer et al., 2020; Majchrzak & Shepherd, 2021; Richterich, 2020), as well as community engagement in bricolage activities. One example is the regular reuse of knowledge and code (e.g., Faraj et al., 2016; Haefliger et al., 2008; Raymond, 1999; Stanko, 2016), whereby "participants [often] retrieve available [knowledge] elements (e.g., previous posts, FAQ documents) and recombine them to fit their immediate needs" (Faraj et al., 2016, p. 7). Likewise, studies on communities provide evidence for the potential value of various bricolage forms of resource development, for example, *individual bricolage* by Linus Torvalds, who reused "code and ideas from Minix, a tiny Unix-like OS for 386 machines. Eventually all the Minix code went away or was completely rewritten – but … provided scaffolding for the infant that would eventually become Linux"

(Raymond, 1999). Further, the community characteristics discussed above (decentralized and informal task division, task allocation based on self-selected member roles, voluntary contributions, virtual environments, and diverse intrinsic motivation) suggest conditions for the formation of *convention-based collective bricolage* created by a sum of the separate idiosyncratic repertoires of the participants. At the same time, *familiar-based collective bricolage*, relying on shared collective repertoires, might be equally possible since peer feedback encourages additional contributions and provides a background for developing shared experiences and collective familiarity. Further, information provision based on shared IT enables coordination and shared visualization. For example, members coordinate and typically increase their contributions if the latter are made visible to other members through trackers or through public recognition (Garud et al., 2008; Faraj et al., 2016). In addition, peer-production contexts enable the formation of trust and tacit knowledge flows (Faraj et al., 2016; Jarvenpaa & Leidner, 1999). In particular, Faraj et al. (2016) argue that, even in the absence of a shared physical space, as participants socialize using IT and make it a natural part of their everyday life, they engage in hard-to-codify tacit knowledge creation (e.g., competence, experience), typically transferred in other settings via face-to-face observation and imitation. Faraj et al. (2016) argue that such *IT domestication* is crucial for the community's knowledge creation processes and "a culture of sharing and *remixing* in which participants experience extensive satisfaction from the continuous discovery of novel and surprising insights, ideas, and solutions" (p. 674). Likewise, trust develops in peer-production communities despite the absence of physical co-presence when like-minded individuals rely on IT capabilities of "anytime, anywhere" access to engage in repeated social interactions and collective action, and develop shared goals, passion, and a sense of belonging (Faraj et al., 2016; Jarvenpaa & Leidner, 1999). Finally, given that communities are

highly flexible sites with evolving numbers of participants (e.g., Benkler, 2017; Faraj et al., 2011), changes in community can potentially impact the types of available bricolage repertoires.

To summarize, communities often engage in bricolage, and their organizational settings provide fruitful background for bricolage. Applying the theory of bricolage to community settings will enable the acquisition of valuable knowledge about how communities can successfully develop their missing resources in penurious environments. In particular, this paper sheds light on how communities develop their missing resources with bricolage, and on what bricolage forms and community characteristics enable successful resource development by communities.

3. Research design and methods

3.1. Research setting

In this study, I investigated HomeNets, peer-production communities established to develop and manage residential Internet infrastructure in Minsk, the capital city of Belarus, from 1994 to 2016. HomeNets are particularly suitable for studying how communities develop resources in penurious environments for two reasons. First, they provide a valuable example of peer-production innovation. HomeNets were created by young enthusiasts initially as local versions of the Internet by linking their personal computers (PCs) with coaxial cables, radio modems, and later, optical fiber. During the 1990s and early 2000s, residential Internet was very expensive and underdeveloped in Belarus; at that time, the national ISP, Beltelecom, offered Internet access that was both expensive ($20/day, compared to the average monthly salary of $60) and inconvenient (relying on the use of telephone lines). Having to comply with Beltelecom's monopoly over external Internet channels, commercial ISPs had to buy their traffic from Beltelecom and to resell it. They thus focused on providing corporate Internet access, considering the residential market

unready to generate profit.

Being true "local versions of the Internet," HomeNet DIY infrastructures were used for playing multiparty computer games and sharing films, music, and software among participants; these became very popular among young residents, which led to the rise of spontaneous networks across the city (see Figure 1).

- Insert Figure 1 here -

In 2001, HomeNets started collaborating with commercial ISPs, enriching their services with cheap, shared Internet access. They negotiated special low Internet rates and free modems from ISPs in exchange for providing ISPs with significant numbers of users and community-led, last-mile infrastructures. This collaboration and the possibility of cheap Internet access led to the exponential growth of HomeNets and the creation of a national website (see Figure 2).

- Insert Figure 2 here -

As Figure 2 illustrates, by 2013 in Minsk there were 2,995 HomeNets registered on the HomeNet website, with an average of 600 members and several large communities of 5,000 to 12,000 members each. The exponential growth of HomeNets continued until 2010, attracting hundreds of thousands of new users and eventually leading to the development of HomeNet–ISP infrastructures serving a million users (Scherban, 2010), with "HomeNet webs … covering the entire city" (Gradiushko & Matveev, 2007). HomeNets developed a massive OC consisting of 22,000 users registered on the national website, Homenets.tut.by, and all HomeNet users were connected to local community intranets and to inter-community online communication channels provided by ISPs. In 2010 and 2012, when the government passed a law requiring the personal identification of Internet users, several dozen HomeNets managed to transition to becoming commercially viable Internet providers (Fitzgerald, 2006), which led the national rankings of

consumer reviews in 2016. Following the evolution of HomeNets over time provides insights into a variety of community resources, resource fluctuations, and resource-development processes. Table 3 summarizes key events in HomeNet development, along with changes in their size.

- Insert Table 3 here -

The second reason why Belarus' HomeNets are fruitful sources of information is that these HomeNets—initially ignored by Internet providers and later discriminated against by the government—were creating a variety of missing resources, including material resources, skills, legitimacy, and contacts with other important actors in the field. The longitudinal nature of the HomeNet phenomenon provides a particularly valuable setting for following various resource challenges that communities face over the course of their evolution.

Third, the HomeNet case is valuable for studying the undertheorized role of IT resources in community bricolage, since IT was at the core of HomeNet development, while the longitudinal nature of the case captures the wide set of technologies used by the community. In their early stages of community development, HomeNet infrastructures were composed of residential PCs linked with cables, hubs, and switches. Connections between neighbouring buildings were done through cable "by air" connections and later through underground coaxial cables. As HomeNets evolved, their infrastructures also became enriched with servers, chats, file search-and-exchange apps, DIY equipment, and photo and video galleries. When HomeNets started collaborating with ISPs, their infrastructures became connected to the Internet through modems; local HomeNet websites and the big national website HomeNet.tut.by emerged; Wi-Fi and later fiber-optic connections replaced cable "by air" connections; and multiple services and hardware innovations (e.g., community radio, firewalls, forums, DIY equipment) further enriched the network to satisfy the various needs and demands of a growing number of participants. Figure 3 provides an example

of a typical HomeNet infrastructure from 2010. When HomeNets evolved into ISPs, their infrastructures were rewired with fiber-optic Ethernet connections.

- Insert Figure 3 here -

Finally, being a prominent example of community bricolage, HomeNet settings are also representative of residential Internet infrastructure development around the globe, including in Canada, the Netherlands, Spain, Germany, and the United Kingdom (Powell & Meinrath, 2008; van Oost et al., 2009; see also guifi.net, http://b4rn.org.uk, http://firstmile.ca, and personaltelco.net/wiki).

3.2. Data collection and data sources

I collected data in 2010 and 2011 and again in December and November 2016, relying on multiple data sources: interviews, documents, archival data, and participant observations. Table 4 provides details on the data sources; key details are provided in the rest of this section.

- Insert Table 4 here -

In total, I conducted 82 in-depth interviews with HomeNet users in Russian and Belarusian. Interviews ranged from 30 minutes to two hours, with an average length of 40 minutes. All interviews were semi-structured and open-ended, with 80% being recorded. All interviewees had a minimum of one year's experience dealing with HomeNets, and the majority (about 90%) had more than five years' experience (some HomeNet administrators had 15–16 years of experience). In total, I conducted 77 face-to-face interviews; a further three were conducted by phone. I used a snowball sampling method (Goodman, 2011; Heckathorn, 2011) to ensure the trust and openness of HomeNet community members despite their concerns about recent laws prohibiting HomeNet activity. Each interviewee was asked to provide contact information for other knowledgeable members. To be systematic, the collected data was controlled for HomeNet creation date and size.

Interviewees were asked to tell the story of the creation and development of their HomeNet with regard to the challenges they faced and practices of generating resources (funds, knowledge, HomeNet routines, services, hardware, software, etc.) and were asked to provide supporting examples and cases. Interviews with experts (see Table 4) aimed to clarify the underlying challenges and conditions motivating HomeNet development. To cover the longitudinal HomeNet phenomenon, interview questions covered the period between 1994 and 2016.

The interview data was complemented by intensive *documents* from HomeNets (e.g., HomeNet documents, photos and videos) and archival data (e.g., newspaper and journal articles, and national laws regarding Internet regulation). Studying documents and archival data was important as this helped me to understand details about the contexts in which HomeNets operated, which challenges they encountered, and in what time period they experienced difficulty. HomeNet documents, such as photos and videos of HomeNet construction, provided insight into how HomeNet participants perceived the challenges they encountered and how they addressed these. Finally, the data acquired from interviews and document review was supplemented with 17 hours of participant observations conducted in 2010 and 2011. These helped me to gain further insight into how HomeNet participants addressed some resource challenges in practice (e.g., by shadowing HomeNet equipment renovation in attics) and how they collected resources (e.g., by shadowing users paying monthly fees). Table 4 provides details and illustrative examples of these data.

3.3. Data analysis and coding

In carrying out data analysis, I combined the procedures of analysing process data (Langley, 1999) and the inductive identification of conceptual categories grounded on empirical evidence and theoretical literatures (Gioia et al., 2013; Miles & Huberman, 1994). I started this research

with an inquiry into how HomeNets managed to develop large-scale Internet infrastructures since, having been a user of HomeNets from 2000 to 2007, I knew from personal experience that HomeNets relied on small user fees and volunteer work. During the early interviews, I discovered that these developments were an emergent process with no top-down actor guiding the process, and that HomeNet creators lacked multiple resources. This discovery led me to incorporate theories of peer production and bricolage into my analysis. Later in the analysis, I created a narrative explaining how HomeNet participants developed resources to build Internet infrastructures, what resources they lacked, and how they addressed these. Following the narrative, I identified three breakthrough events (Langley, 1999): community emergence, HomeNet–ISP collaboration, and the introduction of the 2010 prohibiting government law. The events created discontinuities in HomeNet evolution in terms of available and missing resources and the key challenges driving HomeNets to develop these, and they shaped the evolution of the HomeNet community into three phases: *emergence*, *growth*, and *radical transformation*. For example, HomeNet participants initially created all resources from scratch; resource development in HomeNets collaborating with ISPs focused on the development of missing resources to organize and manage the larger variety of heterogeneous actors. On the other hand, during the radical transformation period, the focus was on survival and change.

After identifying key breakthrough events, I carried out a comparative analysis of each phase, considering what types of challenges were faced by HomeNets and which resources were needed to address these. The conceptual categories emerged from continuous dialogue between the insights from the data and existing literature on peer-production communities and bricolage. As a result, the identified constructs gradually increased in levels of interpretation (Miles & Huberman, 1994), conceptualizing empirical evidence showing the challenges that drove

resource development within HomeNets over their evolution; the processes of individual or collective bricolage that were engaged in developing the missing resources; the community organizational characteristics that enabled the bricolage processes; and the types of resources that were constructed. The empirical themes of the different phases of HomeNet evolution were compared, challenged, and merged to reach consistency and stability, resulting in second-order and in some cases third-order categories. The final aggregate categories were *HomeNet resource challenges*, *developing resources with individual and collective bricolage*, and *created community resources*. Details of the data structure and constructs are presented in Figure 4 and discussed in the findings and analysis section.

- Insert Figure 4 here -

4. Findings and analysis

The analysis reveals that, over the course of their development, HomeNet communities operated in penurious environments and faced the challenges of missing material resources, expertise, and legitimate resources. As Figure 4 illustrates, solving the challenges of missing *material resources* included raising funds and locating material resources to build the HomeNet infrastructure and equipment; the re-structuring of these as a result of changes in HomeNet participants; the acquisition and creation of necessary software; the management of resource fluctuations (e.g., equipment and infrastructure damage, the free-rider problem, and resources and contributions from diverse participants); and the raising of funds to register the business. Solving the challenges of missing *expertise resources* included developing and gaining access to operational, construction, and managerial knowledge and, at later stages, developing business expertise and attracting investors. Finally, solving the challenges of missing *legitimacy*—a key resource for gaining other resources for organizational creation, survival, and growth *(*Zimmerman & Zeitz,

2002)—included developing legitimacy in the eyes of important actors, such as Internet providers, municipalities, and the government to gain access to otherwise missing material and expertise resources. Following the key breakthrough events outlined above (Langley, 1999), namely creation, cooperation with ISPs, and government laws, the evolution of HomeNet communities proceeded though three subsequent key phases: *emergence*, *growth*, and *radical transformation.* The three phases were different in terms of number of community participants, available resources, and specific resource challenges (see Figure 4). At each phase of their community development, HomeNets engaged in diverse bricolage forms and processes to develop missing resources to address the challenges they encountered. Table 5 summarizes the resource challenges, bricolage forms, and bricolage processes employed by HomeNets to develop their missing resources; the rest of the section discusses these in more detail.

- Insert Table 5 here -

4.1. Resource development during community emergence

The idea of creating HomeNets emerged among groups of young friendly neighbours interested in playing multiparty games together. Playing multiparty games in computer clubs was popular in Belarus in the early and mid-1990s; however, as several HomeNet creators mentioned in the interviews, as more of their friends were buying home PCs, they had the idea of developing a DIY network to play together.

4.1.1. Convention-based collective bricolage during community emergence

To reach their goals, HomeNet creators faced the challenge of finding the necessary material resources. Typically between 15 and 20 years old, the creators did not have significant money to invest in professional hardware and software, and thus were *accumulating individual resources,* (see Table 5) to enable HomeNet emergence and functioning. For example, the participants

shared equally the costs of buying cables, hubs, and construction equipment (e.g., drills) to link their home PCs through tinkering and trial and error. They used their PCs, which were "cheap and lacking even simple built-in modems" (HomeNet administrator), as the key infrastructure points. Lacking funds for expansion and growth, HomeNet participants also agreed on the size of the material contribution for new members to pay for the cost of cables and linking materials (typically between $5 and $10). During this early phase, due to a lack of specialized staff, new members were also expected to contribute their time in building the connection (e.g., drilling, linking cables), especially if that required connecting a member from a new building.

4.1.2. Familiar-based collective bricolage during community emergence

The above developments stimulated engagement in familiar-based collective bricolage. Thus, participant involvement in the construction of cable connections between neighbouring apartments and buildings enabled their co-presence in the same time and space, as well as learning through informal interactions. Such *shared spaces* and *informal interactions* enabled HomeNet participants to develop the missing knowledge in construction and functioning of computer networks through collective tinkering and trial and error. For example, this is how the participants developed their own ways of crimping cables and building a cable connection between multi-storey buildings:

> We developed a special technique: two people on a roof of one building were throwing a rope from the ground; the same was done by another two people on a roof of another building. Another one on the ground would attach the ropes to the two sides of the cable and those on the roofs would pull it up. (HomeNet user)

> Once a side wind was so strong that I almost fell down from the roof following the rope with a cable. We did not have any safety equipment, and I was just lucky that my friend managed to catch me at the very last moment. Since then, we always did it in twos or threes. (HomeNet administrator)

Co-presence, informal interactions, and collective problem-solving led to the development of a collective familiarity with resources, emerging know-how, and technical

solutions, thus enabling familiar bricolage. As the community grew in scale, groups of core members developed, consisting of early HomeNet creators and supporting volunteers. Participants from these groups naturally became HomeNet administrators or undertook volunteering roles supporting and developing the network. Calls for volunteers would typically be announced in the HomeNet chats, so anyone interested could join, thus developing a culture of peer support. In this regard, organizational community specificities such as IT-enabled information sharing, self-selected task distribution and allocation, and intrinsic motivations encouraged the development of familiar-based collective bricolage.

4.1.3. Individual bricolage during community emergence

Individual bricolage importantly complemented, and in some cases even stimulated, convention-based collective bricolage. For example, "to play multi-party games via their connected PCs just like they would in a real, but free of charge, computer club" (HomeNet administrator), early HomeNet creators reinvented individual uses of their home PCs into collective activities. Many HomeNet participants looked for and appropriated resources from their own homes or from work and then retasked these resources to solve immediate problems with the network buildout (*reinventing the value of individual stocks*, see Table 5), as this example illustrates:

> Once we were creating a cable connection between a nine-storey and a five-storey building. The construction required long ropes to be dropped from both roofs to the ground, attaching them to the cable and then pulling them back to create a cable connection. But where does one get such a long rope? One of the volunteering members was a fireman. He borrowed several long fire hoses from work and this is how we linked these two buildings. (HomeNet administrator)

Individual bricolage was also crucial for acquiring access to missing expertise and skills in the design, construction, and functioning of HomeNets. For example, HomeNet creators often involved their friends and relatives with specialized educational backgrounds and professional experience in HomeNet construction (e.g., *relying on personal connections "on hand" to attract*

lacking expertise and skills). As the following quotation illustrates, this expertise was often applied in unconventional ways:

> You see, the cable connection between these two roofs comes through a very dendritic tree? We tried thousands of means—a usual way; throwing the cable; a child's plane with remote control … but did not succeed in building the connection. Then I remembered that my uncle used to be a national champion in biathlon, so we asked him to shoot an arrow with an attached cable from a window attic of the building into the attic window of another. This worked perfectly fine! (HomeNet user)

Finally, individual bricolage was useful for addressing legitimacy challenges during the emergence phase of HomeNets. Thus, when linking participants in different multi-storey buildings, HomeNets faced the challenge of gaining access to attics, basements, and underground telecommunication channels, managed by local municipal organizations, to install equipment (e.g., switches and shared modems). HomeNet participants overcame these challenges by involving their relatives and friends working for municipalities to gain (mostly informal) access to the facilities (i.e., *relying on personal connections "on hand"*), as this example illustrates:

> We had several users who worked in municipal services, or whose parents or relatives worked in those organisations … and looked for ways to establish personal *connections*. (HomeNet administrator)

> Basements and attics are typically closed … Officially, any cable construction works should be approved by the municipality and the constructor should have a licence for this work … but many municipal workers use HomeNets themselves. (HomeNet administrator)

4.2. Resource development during community growth

Important resource challenges during this phase were the lack of legitimacy as important business partners in the eyes of ISPs, as well as the challenge of managing fluctuations in material resources. The latter dramatically increased in scale and heterogeneity due to HomeNet–ISP collaboration but needed to be organized and managed. HomeNets engaged in familiar-based collective bricolage when addressing the legitimacy challenge, and in a combination of

convention-based collective and individual bricolage to address the challenge of managing fluctuations of material resources. The rest of the section discusses these in detail.

4.2.1. Familiar-based collective bricolage during community growth

In 2001, with newly emergent ADSL Internet technology, HomeNets saw an opportunity to negotiate cheap Internet access from ISPs in exchange for the last-mile infrastructure that they were missing. ISPs had not invested in residential Internet infrastructure in the 1990s as they believed that the market was not ready. In addition, given the monopoly of the state ISP, Beltelecom, over the telephone infrastructure through which dial-up and ADSL residential Internet infrastructures could have been developed, ISPs focused on providing Internet access to corporate clients rather than on developing access for residents.

Administrators of several big HomeNets, with member numbers ranging from 500 to 2,000, visited ISPs and proposed a collaboration whereby DIY HomeNet connections would take Internet bandwidth from ISP modems and share it among HomeNet participants. To "sell" their idea to ISPs, administrators engaged in identity bricolage. As the following quotation illustrates, they presented themselves to ISPs as opinion leaders of big communities of potential customers (i.e., by *recombining the existing identity with useful narratives*):

> The idea was to make them [ISPs] believe that we [administrators] are representatives and important leaders of big communities of their potential users and that we can influence and guide this crowd to become their loyal consumers. (HomeNet administrator)

Administrators were able to create very powerful and effective narratives that they could present and offer to ISPs, and this became the basis for successful long-term collaboration. By 2002, special offers of Internet access for HomeNets were published on ISP websites. Access to the Internet through HomeNet–ISP infrastructures became the main form of residential Internet access, boosting the number and diversity of new members and thus bringing many new

resources to the community.

The same bricolage process (*recombining the existing identity* of HomeNets as collective selves *with useful narratives*, see Table 5) was also helpful for maintaining independence from ISPs, who could dictate the prices and conditions of collaboration, or even attempt a takeover. To prevent this, HomeNets started collaborating with multiple ISPs simultaneously:

> We soon understood that if we collaborated with one ISP, we might find ourselves completely dependent on that ISP. Therefore, we decided to invite multiple providers into our network. This created favourable conditions, as the ISPs competed for our business. (HomeNet administrator)

The collaboration was triggered by an identity bricolage, whereby the existing community identity of HomeNets as communities for participants with similar needs (e.g., multiparty games) was recombined with novel demands from new and heterogeneous participants (e.g., housewives, retired people, local entrepreneurs, schoolchildren). Through informal interactions on community forums and chats and at offline meetings, HomeNet participants discovered and discussed highly heterogeneous needs and preferences in Internet services in terms of prices and speed (for education, work, communication, etc.). Seeking to resolve these heterogeneous demands, HomeNets made requests to multiple ISPs with diverse traffic offers supporting different consumption patterns (e.g., those preferring cheap night access or daytime access). As a result, HomeNet resources increased, not only in the variety of Internet traffic offers but also in the number of engaged heterogeneous members who could bring a different sort of social, cognitive, and material capital to the network.

Finally, as the quotations below illustrate, the new community identity motivated a deep culture of informal interactions, sharing community resources, such as information, files, and knowledge, and organizing co-present activities:

> Someone needed nice office paper for their printer—they found this in the neighbouring home via network. Someone needed garlic urgently—a neighbour

> from the next doorway provided some after seeing the call in the chat. Someone bought a DVD of a new film—the whole area watched it … Teenagers initially passionately gambled in the network computer games; then, after a while, they got acquainted and started to meet outside … Besides, they did their homework together via network … Older users … who were keen on cycling quickly organized into mini communities and started exchanging spare parts and organizing trips together … Housewives exchanged pieces of advice and recipes … To cut a long story short, in our area, HomeNet developed into a living organism. (Extract from publication about a HomeNet in a local newspaper [Demidov, 2008])

Vibrant forum discussions on amateur websites on small HomeNets (e.g., http://dom15.narod.ru) and later the national HomeNet website (Homenets.tut.by, with 22,000 registered members by 2009) provided visible and continuously updated information and knowledge repositories (*developing resources through shared spaces and informal interactions*). In particular, they helped accumulate information and knowledge on a variety of HomeNet topics, including the know-how of HomeNet construction, shared practices of creating lightning rods, DIY solutions, and the best practical knowledge of hardware and software use.

4.2.2. Convention-based collective bricolage during community growth

The culture of sharing, developed during the previous phase, combined with decentralized self-selection of tasks, stimulated HomeNet participants to contribute and creatively use their own resources for collective purposes (*accumulating participant individual resources*). For example, HomeNet participants co-funded equipment renovations in cases of damage or breakdown:

> I remember this … night after a very strong storm. People woke up in the morning and discovered that they did not have the network connection any more. They started calling me to know what had happened. They started bringing and collecting money, as little as one could donate … In two days, the fund was ready, the new cables and equipment were in place, and the HomeNet became alive again. (HomeNet 10)

Similarly, HomeNet participants pooled their available individual resources for community uses. For example, community media repositories emerged from practices of sharing participants' collections of interesting media (programs, films, music, books, and so on):

> People share their own resources—interesting films, music, videos, books, etc. It's a common practice. (HomeNet user)

> If you've got an interesting file [a film, music or book] on your computer you … display a link to this resource in a common [chat] channel and, if someone is interested, they can open it and have a look. (HomeNet user)

As a result, the number of available resources increased as new members joined, thus increasing the overall HomeNet value. As a HomeNet administrator summarized:

> The value of HomeNet is equal to the square number of its members. It means that a HomeNet with three participants is more than twice as resource rich as a network with two, and a HomeNet with ten people is about four times better than a network with five participants.

Notably, technology was important for enabling, organizing, and controlling resource contributions shared by the participants (*managing contributions through technology*, see Table 5). For example, the national HomeNet website enabled all collaborating ISPs and their contact details to be seen, as well as existing neighbouring HomeNets, which started actively merging into bigger ones:

> Thanks to the Homenet.tut.by website, I found out that there existed a neighbouring network … and contacted the administrator of this network, via the homenet.tut.by messenger in 2005. We … merged the networks later. I could see their cables from my window but I did not know that the network existed. (HomeNet administrator)

As HomeNet participants grew in number, communities faced challenges related to the management of resource contributions and their fluctuations. For example, as HomeNet participants increased, some new members engaged in free-riding, preferring to "use the network resources without contributing" (HomeNet administrator), which also had a negative effect on resource sharing in the network. As an administrator stated:

> When someone opens access to an interesting piece of content, many people want to watch it … As a result, the [hosting] PC is under such continuous pressure that its owner cannot use it normally. What happens? He closes the access and the valuable resource is lost.

Some administrators used IT to encourage the sharing of community resources and

even to control these. For example, some administrators introduced controlling software, which required a new member to share at least one resource with the server before that person could start downloading or streaming community resources. Some administrators implemented controlling switches to ensure that members who neglected the norms of sharing (or behaved inappropriately in chats) were temporary disconnected. Other administrators displayed video files or simply Word files describing their efforts to develop and maintain HomeNet infrastructures to encourage participants to pay the agreed-upon monthly fee. Yet others posted files tracking the contributions of each participant in order to raise collective awareness:

> An Excel file … was posted on the local community website [so] everyone could see who paid and who did not [since] all the costs and revenues were documented, users could see where the money was going to solve every emerging problem which increased their understanding and motivations to contribute. (HomeNet administrator)

> To encourage people to pay at least the monthly fee … I created an accounting document which I put on the net server available to all users and renewed it on a regular basis displaying [each] member's contributions. (HomeNet administrator)

4.2.3. Individual bricolage during community growth

Decentralized and informal task division and allocation enabled the involvement of HomeNet members with heterogeneous individual resources, backgrounds, and skills; this helped to address the challenges of missing material resources and legitimacy by engaging into individual bricolage. For example, HomeNet participants solved emergent legitimacy problems by relying on personal *connections* "on hand." As a HomeNet user recalls, such *connections* were useful for ensuring the security of HomeNet participants during a community meeting:

> Once we had a big meeting during Independence Day. Then, suddenly the whole bus of militia [local police] arrived and they all ran out with guns and surrounded us, thinking that we were a part of the political protests that happened that day! Luckily, one of our users was an officer. He recognised a militia officer whom he knew and explained everything.

HomeNet participants used their individual resources to generate value for the community (*reinventing the value of individual resource stocks*), as the following example illustrates:

> At one point, we needed a good-quality wire that was also resistant to bad weather, like snow and storms. Fiber-optic wire would meet these demands perfectly, but the price was too high … One of our users was a former member of the military, and he had a long piece of old Soviet military field cable, P-296, saved at his place. The cable fit our needs perfectly: it was insulated, resistant to weather conditions, and proper—made of copper. It significantly improved the signal quality in the network. (HomeNet administrator)

Some HomeNet members also took the initiative to develop IT innovations that helped HomeNets generate missing resources and increase the richness of commonly available resources (engaging in *individual bricolage for collective purposes*). For example, to compensate for very restricted or no time resources, administrators created homemade videos covering a range of common problems, such as sudden disconnection from the Internet or problems with IP addresses. These video tutorials offered users detailed explanations and illustrations of possible ways to fix a problem before contacting the administrator. Likewise, Figure 5 illustrates the transformation of an old PC processing unit, donated to the network by a member, into a community FTP server, while Figure 6 presents an example of a bricolage-made lightning rod ($4 cost). The innovation was attached to network switches and placed in attics to prevent the accumulation of static electricity and equipment damage ($25–30 cost) from lightning strikes.

- Insert Figure 5 here -

- Insert Figure 6 here -

Notably, even the national HomeNet website, which played a crucial role in community resource development, was created as a part of individual bricolage:

> Any IT person is a bit of a collector of various IT stuff that he applies when a good possibility arises … I created the HomeNet website as my hobby project … I applied newly learned IT things that I found cool … I started with an address database to help those who wanted to create a HomeNet to find each other … Later, different functionalities like forums, chats, voting systems were added. (Website

developer)

Other examples of member-generated IT innovations included switches, video and audio tutorials, and search applications that enabled searching for files from networked computers. Resources assembled through individual bricolage by HomeNet participants generated value for the whole community and encouraged other members to contribute.

Finally, openly sharing various HomeNet know-how on the national HomeNet website forum motivated some external actors to engage in individual entrepreneurial bricolage, which also extended the availability of HomeNet resources. For example, as soon as emergent DIY solutions on how to construct the network were described in detail on the HomeNet website, many commercial propositions from amateurs appeared on the website:

> So if two neighbours would like to have a HomeNet they can have it built "from door to door" for about 10 US dollars. (HomeNet user)

4.3. Resource development during radical transformation

In 2010 the government introduced a new law obliging all ISPs to provide individual identification for all Internet users. The law put HomeNets under existential risk: using allocated and flexible IP addresses to share traffic from the same modem to access the Internet became illegal. Following the introduction of the law, some HomeNets accepted the so-called "help in legalizing" proposed by ISPs and became integrated into their infrastructures. Other HomeNets went underground, continuing to operate and collaborate unofficially with ISPs for a couple more years before eventually dissolving. Yet other HomeNet ISPs managed to address the legitimacy challenge, find necessary business investment, and transform into successful HomeNet ISPs. Notably, these HomeNets that transformed into ISPs engaged in familiar, individual, and convention bricolage when developing their resources to address the challenges.

4.3.1. Familiar-based collective bricolage during community radical transformation

The new law created the dramatic challenge of changing HomeNet identity since collectively shared Internet access was at the heart of HomeNet existence, activities, and shared resources. Nevertheless, some administrators saw an opportunity in the challenge of developing from communities into what they called "HomeNet ISPs":

> … a community ISPs where the core of community values and innovation were preserved. (HomeNet ISP manager)

> I talked to almost every member individually, explaining how we as a community could preserve what we have done with our hands. The other two alternatives were disappearing or giving everything to the ISP. (Creator of HomeNet ISP)

Engaging in identity bricolage by enhancing HomeNet community identity with a new business identity (*recombining existing identity with useful narratives)* enabled HomeNets to address the legitimacy challenge and extend the variety of available resources. In particular, it enabled HomeNets to preserve their loyal participants and their trustworthy relationship with them, as well as their agreement to continue investing their resources and engaging in community innovation. Although the collectively shared property was registered as owned by administrators (who also invested their own funds and raised external sponsorship), the important community role in HomeNet ISP decision-making and innovation continued to prevail. This role is often acknowledged on HomeNet ISP websites, noting the key role of users in developing the company and their historical background as HomeNets. For example, Unet.by, a pioneering HomeNet ISP and one of the highest-ranked ISPs in Belarus, refers to its HomeNet history on its company website and states that "there is huge involvement of our users in the development of the company and its innovations" (https://unet.by/about).

4.3.2. Individual bricolage during community radical transformation

In 2008 and 2009, when the first rumours of possible government sanctions against HomeNets appeared in the press (Gradiushko & Matveev, 2007; Ruzhechka & Kozlovich, 2009), local

municipalities started conducting audits to locate HomeNet cable infrastructures that did not meet fire and security standards. Those HomeNet participants who worked for municipalities, telecommunication organizations, the militia, or the security forces relied on their information channels to help HomeNets pass planned inspections from government bodies (*relying on personal connections "on hand" to increase legitimacy*, see Table 5). For example, municipality workers who were also HomeNet participants would guide the inspectors to places where no HomeNet infrastructure was visible, or where it had been developed in line with all technical requirements, avoiding those developed in an *ad hoc* manner.

HomeNet ISPs engaged in individual bricolage to attract missing material resources. For example, since the reorganization and modernization of HomeNets into ISPs often demanded significant material investment, administrators of those communities attracted investment by asking their friends and relatives to become investors (*relying on personal connections "on hand" to attract lacking resources*). In addition, former administrators and now managers of various HomeNet ISPs engaged in the same bricolage process (*relying on personal connections "on hand" to attract lacking resources*) to access missing and hard-to-find equipment. They organized a closed social media group where they exchanged relevant market and legal information, and organized the informal bartering of rare or expensive specialized equipment. Indeed, community characteristics, such as decentralized and informal task division and allocation, self-selected roles, and leading intrinsic motivation of the HomeNet ISP creators, played an important role in enabling HomeNet ISPs to engage in individual bricolage to address the challenges posed by missing resources.

4.3.3. Convention-based collective bricolage during community radical transformation

HomeNet ISPs used technology to attract missing material and expertise resources from their users

(*managing contributions through technology)*. They maintained and developed intranets (online spaces with chats, media galleries, file repositories, etc.) from HomeNet communities. These allowed the maintenance of the culture of HomeNet participant engagement in community activities, resource contributions, and innovations. For example, HomeNet ISPs held regular innovation contests and used members' innovative IT developments to save on otherwise expensive proprietary corporate solutions. They also supported the most active forum users with small and symbolic prizes, and introduced billing systems that would provide financial incentives for members who shared their content resources with others. These initiatives enabled HomeNet ISPs to encourage contributions from participants and to manage these with technology. Finally, the closed social media group organized by managers of diverse HomeNet ISPs helped them to exchange and acquire missing expertise in managing business, legal, and operational issues.

5. Discussion

This paper discusses HomeNet communities, which were developed by residents in Minsk, Belarus, to create the Internet infrastructure that ISPs failed to provide. Over years of development, HomeNet communities faced multiple and diverse challenges related to missing material resources, limited expert knowledge, and lack of legitimacy. Nevertheless, HomeNets managed to evolve from small intranets constructed by neighbours with no funds or professional education to million-user residential Internet infrastructures, and later to successful HomeNet ISPs. The findings illustrate that communities successfully develop their missing resources by engaging in diverse and evolving combinations of forms of bricolage. The ability to build on both individual and collective bricolage forms of resource development enables communities to successfully incorporate the individual and collective efforts of their participants in resource building, and thus address the challenges specific to the current phase of the continuously

evolving and fluid community.

5.1. The model of community resource development with bricolage

Based on the findings, I propose a model of community resource development with bricolage. The model illustrates specific combinations of individual and collective forms of bricolage and related bricolage processes that enable communities to develop their missing resources according to their evolution phases and the nature of experienced challenges (see Figure 7).

- Insert Figure 7 here -

In particular, the model illustrates that, to address material and legitimacy challenges, communities engage in similar combinations of bricolage forms (but employ different bricolage processes) across community evolution; at the same time, addressing the challenges of missing expert resources proceeds with different bricolage forms as communities evolve.

In this case, across all evolution phases, communities addressed the challenges of missing material resources by engaging in a combination of convention-based collective and individual bricolage forms. However, as Table 5 and Figure 7 detail, HomeNets relied on diverse and specific bricolage processes within the above combinations. For example, during the *emergence* phase, HomeNets developed their missing material resources by engaging in the processes of *accumulating participant individual resources* (with convention-based collective bricolage) and *reinventing the value of individual stocks* (with individual bricolage); at the same time, during the *radical transformation* phase, HomeNets developed their missing material resources by engaging in the processes of *managing contributions through technology* (with convention-based collective bricolage) and *reliance on personal connections "on hand" to attract lacking resources* (with individual bricolage). In a similar vein, across all evolution phases, communities addressed the challenges of missing legitimacy resources by engaging in a combination of

familiar-based collective and individual bricolage forms (see Figure 7 and Table 5 for details).

At the same time, the model illustrates that communities develop missing expertise resources by engaging in different bricolage forms across evolution phases. For example, during the *emergence* phase, HomeNets developed their missing expertise resources by engaging in familiar-based collective and individual bricolage forms; at the same time, during the *radical transformation* phase, they addressed the same challenge by engaging in convention-based collective bricolage. Developing missing expertise knowledge might be more challenging and difficult to operationalize, due to their specificity and knowledge intensity, and thus, it is natural that communities need to engage in various bricolage forms to address and adjust the necessary resources to the nuances specific to expertise challenges at different phases of community evolution. In contrast, the nature of material and legitimacy resources is similar across diverse phases of community evolution, and thus communities engage in similar combinations of bricolage forms. They address the specificities of these resources by engaging in different and specific bricolage processes within the applied combinations.

The above model also illustrates the community ability to employ diverse and multiple individual and collective forms of bricolage resource repertoire creation. This ability is important as a community evolves, since it enables the community to develop various missing resources and incorporate both the individual and collective efforts of the participants in resource building with bricolage. Finally, the model illustrates that engaging in certain forms of bricolage triggers engagement in other bricolage forms and enables the creation of different types of resources. For example, creating missing material resources with a combination of convention-based collective and individual bricolage during the community emergence phase was crucial for the communities' ability to create expert and legitimacy resources and for subsequent community

evolution. Further research is needed to examine the impact of potential interdependence between different forms of bricolage on community resource creation.

5.2. Contributions to community studies

First, this study contributes to the emerging research on communities that rely on IT to develop value in environments where resources are missing or scarce (Armani et al., 2020; Majchrzak & Shepherd, 2021; Powell & Meinrath, 2008; van Oost et al., 2009). Previous studies have attributed communities' ability to attract and develop resources to community organizational characteristics, (Faraj et al., 2011; Puranam et al., 2014; Raymond, 1999; von Krogh et al., 2012; Wasko & Faraj, 2005), without explaining how these affect resource-development processes. This study is one of the first to link community organizational characteristics to particular forms and processes of resource development; as such, it demonstrates that community characteristics enable access to various bricolage forms that stimulate the development of diverse resources (see Table 5). In particular, community ability to employ diverse bricolage forms to develop various missing resources provides a possible explanation of community success in resource-scarce and crisis situations (e.g., Majchrzak & Shepherd, 2021; Williams & Shepherd, 2021). Table 6 summarizes the impact of community characteristics on engaging in diverse individual and collective bricolage forms.

- Insert Table 6 -

As Table 6 illustrates, *decentralized and informal task division* within HomeNets enabled emerging and flexible ways of matching problems to solutions, and increased variation of resource uses. This was particularly important for HomeNet participant engagement in individual bricolage. For example, HomeNet participants relied on personal *connections* "on hand" to increase community legitimacy in the eyes of municipalities, to attract missing material

resources and expertise, and to reinvent the value of their individual stock to provide the community with missing equipment and other resources. In a similar vein, *self-selected roles* motivated a best person–best resource fit (Benkler & Nissenbaum, 2006), whereby participants engaged in individual bricolage since they were free to choose how to apply their specific individual resources to address the challenges that they found interesting and feasible. It also stimulated resource repertoire creation through convention-based collective bricolage. Further, *leading intrinsic motivations* motivated participants to be creative and engaged, which stimulated participant involvement in individual bricolage with their available resources, as well as in familiar-based collective bricolage to help with collective problem-solving. Finally, *information provision based on IT* as a key communication, coordination, and visualization tool stimulated convention bricolage by managing contributions through technology (e.g., software controlling contributions and the development of servers with files, books, photos, and videos shared by individual participants). It also stimulated familiar-based collective bricolage by providing participants with heterogeneous needs with shared spaces and informal interactions to discuss and exchange ideas.

Second, this study illustrates that engaging in diverse bricolage forms is beneficial for community resource development given the characteristics of community functioning. Thus, community engagement in diverse bricolage forms enabled the involvement of both periphery participants (e.g., individual bricolage) and core participants (e.g., convention-based collective bricolage), which was beneficial for community innovation (Dahlander & Frederiksen, 2012). It was also valuable for dealing with large resource fluctuations, which are typical for communities and have an impact on their success or failure (Faraj et al., 2011; Benkler et al., 2015). For example, engaging in convention-based collective and individual bricolage made it possible to

manage rapidly extending material resources during the HomeNet growth phase, as well as to manage dramatic unplanned deficits in material resources during the community's radical transformation phase.

Third, the findings illustrate the important role of IT in various bricolage forms of resource development. In this regard, the findings support and further extend existing knowledge on the value of IT flexibility for innovation creation (e.g., Duymedjian & Rüling, 2010; Faulkner & Runde, 2009). Thus, in community settings, IT flexibility was important for the creation of various innovations with individual bricolage. Yet, collective engagement of participants in IT bricolage was also important for the creation of common spaces, shared values, and trust (Faraj et al., 2016; Jarvenpaa & Leidner, 1999) in familiar-based collective bricolage, as well as for accumulating, managing, controlling, and visualizing participant contributions in convention-based collective bricolage (see Figure 7).

5.3. Contributions to bricolage studies

This paper makes two contributions to bricolage studies. First, it supports emerging findings about community engagement in bricolage (Faraj et al., 2016; Haefliger et al., 2008; Raymond, 1999; Stanko, 2016) and contributes to undertheorized knowledge about specificities of bricolage within community settings. Studying bricolage within communities, which are highly fluid and evolving organizational settings (Faraj et al.2011), demonstrates the coexistence of different forms of bricolage repertoire creation, and shows that bricolage and its processes evolve as organizational context changes (see Figure 7). This is an important contribution since previous studies on bricolage have suggested that particular organizational characteristics (size, horizontal or vertical structure, technologies, and shared values) define a particular bricolage form (e.g., Duymedjian & Rüling, 2010) and that organizational engagement in simultaneous multiple

bricolage processes impedes organizational growth (Baker & Nelson, 2005). In contrast, the findings of this study illustrate that community engagement in multiple bricolage forms was empowering and enabled communities to address diverse resource challenges across multiple phases of evolution. This finding suggests a need for bricolage research to consider the impact of diverse bricolage forms and processes as contingent on the nature of organizations and their evolution timeline.

Second, the findings of this paper provide a new perspective on organizational bricolage since previous research has focused on studying relatively short-term bricolage, such as developing resources for the specific needs of venture creation, fighting competitors, or establishing market position (Baker et al., 2003; Baker & Nelson, 2005; Garud & Karnøe, 2003; Illia & Zamparini, 2016; Perkmann & Spicer, 2014). In contrast, this study illustrates how bricolage forms and processes evolve over time (see Table 5). In particular, the findings of this paper and the proposed model provide insights into what bricolage forms (and their combinations) and processes are used by communities to address certain types of challenges, and how these evolve as communities mature and their contexts and key challenges change (see Figure 7).

5.4. Practical implications

This study provides insights for community participants and leaders who seek to understand how communities might develop missing resources. The findings of the paper illustrate that communities might develop their missing material resources by motivating their individual members to re-invent the value of their available individual resource at hand, as well as by accumulating and managing participant contributions though existing community technologies, norms, and measures. The development of missing legitimacy resources can be efficiently

addressed by encouraging individual participants to rely on personal *connections* "on hand" to increase legitimacy, and by recombining existing community identity with useful political, cultural, and other local narratives. Finally, the development of missing expertise resources requires a specific nuanced approach to the particular expertise challenges that differ as communities evolve and mature. It might proceed through a combination of such bricolage processes as reliance on personal *connections* "on hand" to attract lacking expertise and skills and developing resources through shared IT and informal interactions (during community emergence phase), and through managing contributions through technology (for more mature communities). In this regard, the findings of the paper suggest particular processes that community leaders might support to facilitate the addressing of particular challenges. For example, since the challenge of lacking material resources is persistent across different phases of community evolution, community leaders might encourage participants to deliberately engage in useful bricolage processes (e.g., developing technologies, norms, and standards for accumulating member contributions, supporting various forms of idiosyncratic views on resources by individual members, and rethinking the value of individual resources for community uses). Table 5 summarizes a range of such processes for diverse phases of community evolution and provides illustrative examples.

5.5. Limitations and further research

This research has several limitations that motivate further research. First, since HomeNets were open communities with no accessibility restrictions, they attracted members with highly diverse knowledge, skills, backgrounds, and expertise and thus were naturally subject to a higher variety of resource challenges in expertise, knowledge, or material resources. In this regard, the findings of this study might be less applicable to closed communities, such as sponsored OCs and

communities where participants might be gated on their level of experience or expertise (Adler, 2015; West & O'Mahony, 2005). Closed communities might experience more specialized challenges and thus engage in fewer bricolage types and varieties of forms of bricolage repertoire creation. Further studies comparing bricolage within communities with different types of governance and accessibility restrictions are needed. Second, this research did not focus on interdependencies between different forms of bricolage. The findings and the proposed model (Figure 7) present some insights in this regard that further research needs to explore.

6. Conclusion

This paper is one of the first to explore how communities develop their missing resources. The findings of the paper illustrate that, facilitated by a fluid community nature and organizational characteristics, communities engage in a multiple and co-existing bricolage forms and processes that help them to incorporate the individual and collective efforts of their participants in building diverse resources and to address the challenges specific to continuously evolving and fluid communities.

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Table 1. Community characteristics and their impacts on resource development

Community characteristics	Impacts on resource development
Decentralized and informal task division	High variety and alternative visions on valuable resources Emerging and flexible ways of matching organizational goals and problems with possible resources for their solutions Possibilities for resource remixing and experimenting
Task allocation based on self-selected member roles, voluntary contributions, and diverse intrinsic motivations	Increased pool of available resources and their creative use Fluctuations in resource stocks, challenges of resource planning Challenges of misinformation and duplication
Leading intrinsic motivations and non-monetary rewards	Increased creativity in resource use and development Significant resource fluctuations
Information provision based on IT as key communication, coordination, and visualization tools	Crucial dependence on IT for visualizing resources and the ways in which they are used, coordinated, and developed by members

Table 2. Bricolage forms employed by organizational actors

Bricolage forms	Organizational contexts	Key features
Individual	Individual entrepreneurs Family and small enterprises	Close familiarity with resource stocks Coherent vision on what constitutes resources in the repertoire and how to use them
Convention-based collective	Big and medium enterprises Corporations	Sum of multiple individual repertoires of organizational members Access to resources in repertoire by negotiated conventions: norms, standards, measures, terminology
Familiar-based collective		Collective familiarity with resource stocks Access to resources in repertoire though shared experience, co-presence, trustworthy relationships and culture, informal interactions

Figure 1. Wired connections linking residents within HomeNets

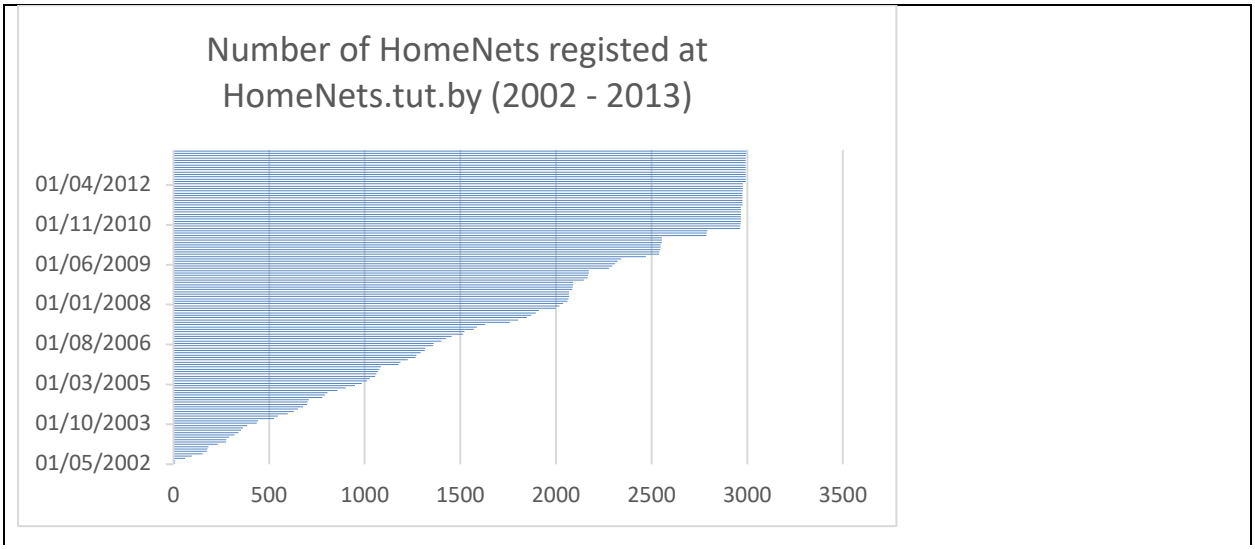


Figure 2. HomeNets registered at the Homenet.tut.by website*

*Source: HomeNets.tut.by developer's statistics

Table 3. HomeNet evolution

Year	Key events	HomeNet size
1994–1995	Creation of first HomeNets in Minsk following unaffordable Internet access and ignorance of residential Internet market by ISPs. Participants (neighbours) play multiparty games and exchange files.	Average 5–20 participants per HomeNet.

1995–1999	HomeNet communities develop throughout the city; some grow into relatively big networks.	Variability in size from 50 to 1000 members per HomeNet.
2001	HomeNets and ISPs start collaboration.	The collaboration boosts HomeNet growth; multiple new HomeNets appear.
2001–2002	All commercial ISPs post special propositions for HomeNets on their websites (reduced prices for Internet access, free modem for every 5–10 users, dedicated technical support for HomeNets).	
2002–2009	HomeNets continue growing in number and diversity of their users as well as in the services available to their users. HomeNets organize for, attract, manage, and control various resources brought in by multiple new heterogeneous members.	>100,000 HomeNet participants in 2007; 44.8% of households in Minsk (out of 1.9m city population) use broadband Internet, the majority through HomeNets.
2009	Many HomeNets introduce fiber-optic technology to their infrastructures, which increases Internet speed and further attracts new participants.	Experts evaluate 90% of household PCs are connected to HomeNets. Total number of Internet users in Belarus is 1.05m users.
2010	President launches law regulating Internet, which requires all ISPs to identify individual users of the Internet. In the new law, community access to the Internet becomes outside the law. ISPs launch intensive negotiations with HomeNets to "help" them with legalizing by incorporating these. Some HomeNets manage to legalize and develop into HomeNet ISPs (Unet, Flynet, Onenet).	Starting from 2011, number of HomeNets and their participants sharply declines.
2011–2016	HomeNet ISPs' reliance on resources and contributions from their members helps them to develop into successful providers, who hold the six top-ranking positions in customer reviewers.	5,000–30,000 users per ISP.

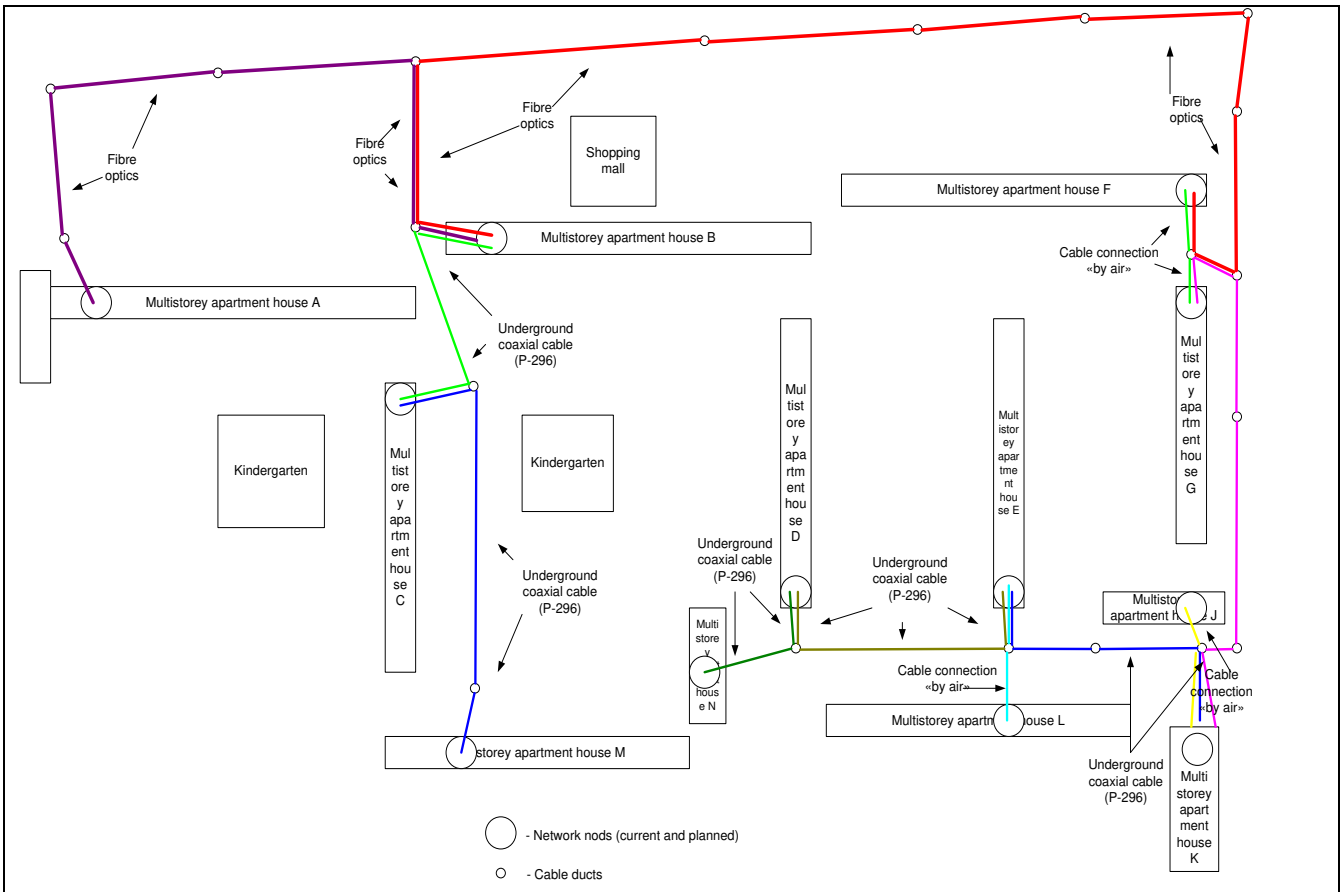
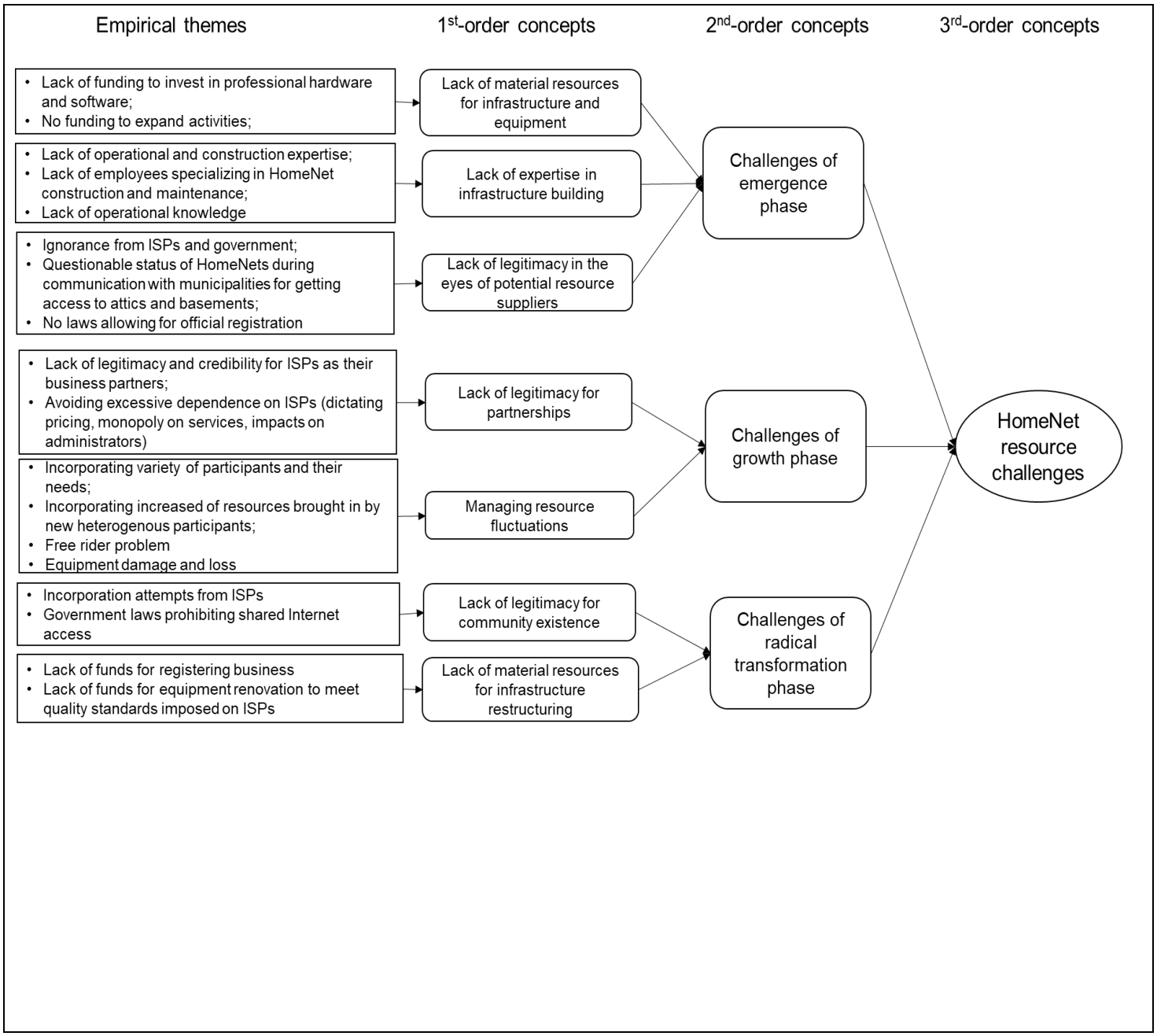


Figure 3. HomeNet infrastructure connections

Table 4. Data sources	
Data	**Details**
82 Interviews	
67 interviews with HomeNets	42 interviews with administrators (justified by their intense involvement in community organizing processes) and 25 with users
4 interviews with experts in the field	The creator of Homenet.tut.by, UNDP consultant on Internet/ICT4D in Belarus and the founder of a ebelarus.org, a popular blogger on Internet provision in Minsk
11 interviews with HomeNet ISPs	Interviews with "OneNet", "UNET". "Domashnaya Set", "LifeNet", "Netberry", and "Flynet"
Documents and archival data	
9 HomeNet financial records	Records in Excel on expenses, repairs and community money for 2008, 2009, and 2009, and 2010
200+ HomeNet photos and 13 videos	Capturing HomeNet creation, development, maintenance and repair works as well as various HomeNet social activities (e.g., "network tea"), self-made video tutorials on frequently asked questions
2 HomeNet statutes	Community documents on creation and distribution of community funds, member and admin responsibilities and defining what they are (i.e., their identities)
17 HomeNet maps	HomeNet maps illustrating wired and wireless connections between apartments and houses
2 HomeNet websites	http://dom15.narod.ru; a complete archived version of the national website of HomeNets2, Homenets.tut.by. comprising information one each of 820 registered HomeNets and their users, forums on technical solutions, community life, juridical and legal information forums, a searchable dynamic HomeNet map, HomeNet rankings and discussion of ISPs
Webpages on HomeNet discourses	Articles in newspapers and journals (e.g., https://42.tut.by/183507; http://www.nestor.minsk.by/kg/2002/50/kg25001.html; https://www.sb.by/articles/dks-mezhdu-anarkhiey-i-diktaturoy.html); publications recording the history of Internet development in Belarus (e.g., https://42.tut.by/397571); interviews with HomeNet experts, Internet technology lawyers, ISPs and HomeNet ISPs (e.g., https://tech.onliner.by/2013/10/24/flynet-by; http://42.tut.by/190425; https://news.tut.by/it/162646.html)
Books and research articles	Providing contextual details of HomeNet development from 1994 to 2015 (e.g., Rybik, 2012; Zabrodskaya, 2013)
Law on Internet regulation	Law on National regulation of Internet 2010 (Decree N. 60)
Statistics of Internet users	Data from the National Statistical Committee and the Ministry of Internal Affairs (e.g., http://n1.by/news/2014/05/17/590046.html)
Ethnographic observations	
17 hours of shadowing HomeNet administrators and users	Shadowing 3 administrators: equipment and cable renovation in attics, posting to HomeNet forum, registering the monthly fee from users, answering calls about Internet connection problems Shadowing 2 users: interactions with other HomeNet users, paying the monthly fee and helping with renovation works


Empirical themes
1st-order concepts
2nd-order concepts
3rd-order concepts
• Lack of funding to invest in professional hardware and software;
• No funding to expand activities;
Lack of material resources for infrastructure and equipment
• Lack of operational and construction expertise;
• Lack of employees specializing in HomeNet construction and maintenance;
• Lack of operational knowledge
Lack of expertise in infrastructure building
• Ignorance from ISPs and government;
• Questionable status of HomeNets during communication with municipalities for getting access to attics and basements;
• No laws allowing for official registration
Lack of legitimacy in the eyes of potential resource suppliers
Challenges of emergence phase
• Lack of legitimacy and credibility for ISPs as their business partners;
• Avoiding excessive dependence on ISPs (dictating pricing, monopoly on services, impacts on administrators)
Lack of legitimacy for partnerships
• Incorporating variety of participants and their needs;
• Incorporating increased of resources brought in by new heterogenous participants;
• Free rider problem
• Equipment damage and loss
Managing resource fluctuations
Challenges of growth phase
HomeNet resource challenges
• Incorporation attempts from ISPs
• Government laws prohibiting shared Internet access
Lack of legitimacy for community existence
• Lack of funds for registering business
• Lack of funds for equipment renovation to meet quality standards imposed on ISPs
Lack of material resources for infrastructure restructuring
Challenges of radical transformation phase

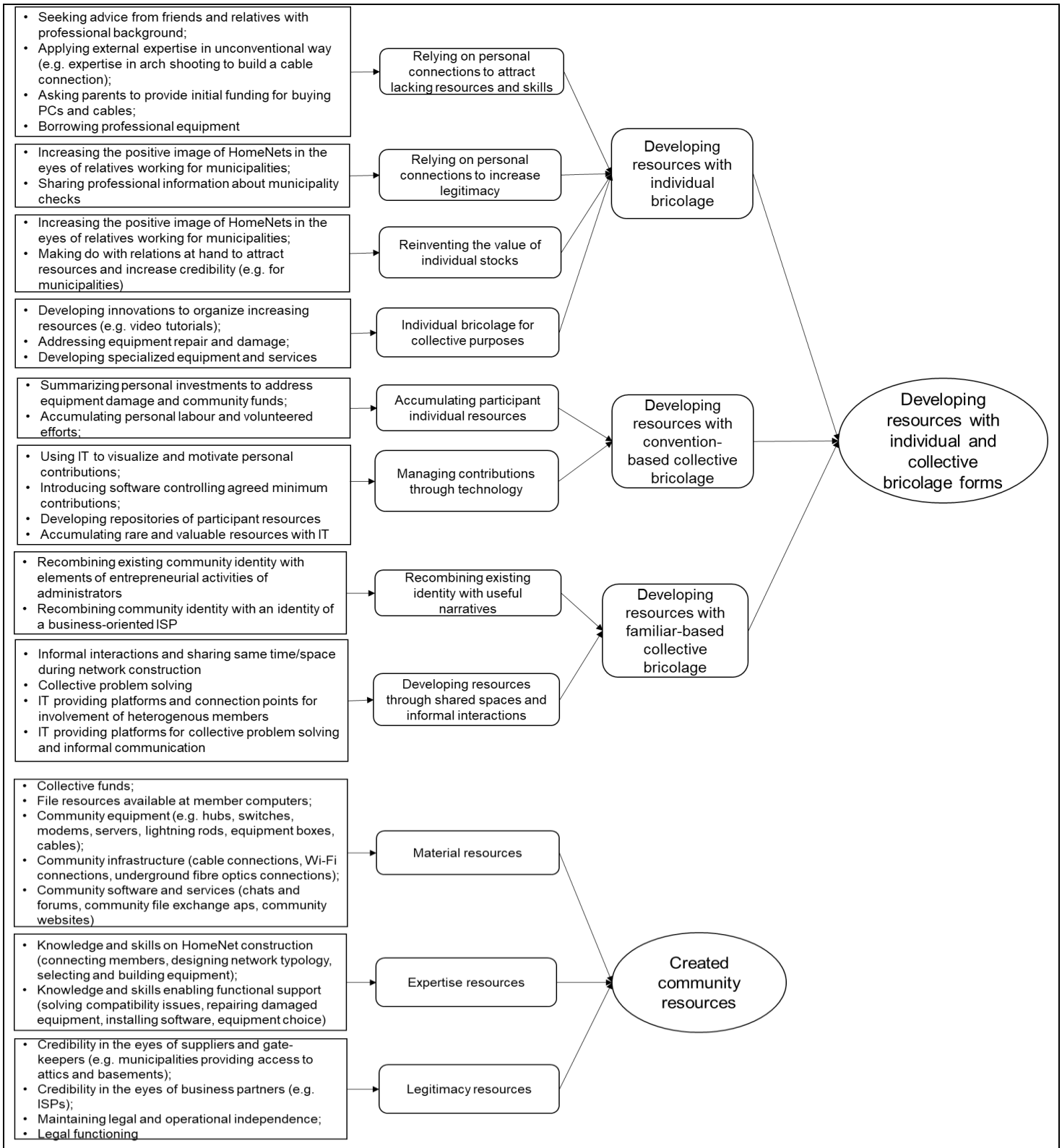


Figure 4. Data structure

Table 5. Bricolage forms and processes for resource creation in HomeNets		
Bricolage forms	**Key resource challenges**	**Bricolage processes and examples**
HOMENET EMERGENCE PHASE		
Convention-based collective bricolage	Lack of material resources (funds, equipment, for infrastructure creation)	• *ACCUMULATING INDIVIDUAL RESOURCES* Example: Summarizing personal investments, agreeing on standard connection fees and labour investment
Familiar-based collective bricolage	Lack of expertise in infrastructure building	• *DEVELOPING RESOURCES THROUGH SHARED SPACES AND INFORMAL INTERACTIONS* Example: Co-presence and informal interactions during cable construction and infrastructure building, collective tinkering, and trial and error
Individual bricolage	Lack of material resources	• *REINVENTING THE VALUE OF INDIVIDUAL STOCKS* Example: Using own old resources (cables, equipment, construction resources)
	Lack of expertise in infrastructure building	• *RELIANCE ON PERSONAL CONNECTIONS "ON HAND" TO ATTRACT LACKING EXPERTISE AND SKILLS* Example: Engaging friends and relatives with professional skills and background
	Lack of credibility for resource suppliers	• *RELIANCE ON PERSONAL CONNECTIONS "ON HAND" TO INCREASE LEGITIMACY* Example: Using personal connections with relatives working for municipalities to persuade them in HomeNet credibility
HOMENET GROWTH PHASE		
Familiar-based collective bricolage	Lack of legitimacy for partnerships Emergent independency risk	• *RECOMBINING EXISTING IDENTITY WITH USEFUL NARRATIVES* Examples: Recombining community identity with entrepreneurial activities of administrators; recombining existing HomeNet identity of community of similar needs with emerging narrative of community of heterogenous members
Convention-based collective bricolage	Managing resource fluctuations and missing resources	• *ACCUMULATING PARTICIPANT INDIVIDUAL RESOURCES* Examples: Collecting funds for equipment renovation; video and file repositories from accumulated individual resources; broadcasting individual satellite TV channels for community members
		• *MANAGING CONTRIBUTIONS THROUGH TECHNOLOGY* Examples: software controlling resource inputs; visualizing resources through national website; IT creating social awareness of participant contributions
Individual bricolage	Emergent legitimacy issues	• *RELYING ON PERSONAL CONNECTIONS "ON HAND" TO INCREASE LEGITIMACY* Example: using personal connections to solve emergent HomeNet problems with militia
	Managing resource fluctuations and missing resources	• *REINVENTING THE VALUE OF INDIVIDUAL STOCKS* Example: using own old resources for community needs
		• *INDIVIDUAL BRICOLAGE FOR COLLECTIVE PURPOSES* Example: developing IT innovations with individual resources for HomeNets
HOMENET RADICAL TRANSFORMATION PHASE		
Familiar-based collective bricolage	Lack of legitimacy for community existence	• *RECOMBINING EXISTING IDENTITY WITH USEFUL NARRATIVES* Example: recombining community identity with business identity of ISP

Individual bricolage	Lack of legitimacy for community existence	• *RELYING ON PERSONAL CONNECTIONS "ON HAND" TO INCREASE LEGITIMACY* Example: using personal connections to show infrastructures meeting the standards
	Lack of material resources for infrastructure restructuring	• *RELIANCE ON PERSONAL CONNECTIONS "ON HAND" TO ATTRACT LACKING RESOURCES* Examples: engaging familiar businessmen in investing community ISPs; exchanging resources through closed social media groups
Convention-based collective bricolage	Lack of material resources for infrastructure restructuring	• *MANAGING CONTRIBUTIONS THROUGH TECHNOLOGY* Example: HomeNet ISP intranets maintaining user contributions;
	Lack of expertise in managing business and addressing legal and operational issues	• *MANAGING CONTRIBUTIONS THROUGH TECHNOLOGY* Examples: HomeNet ISP intranets maintaining user engagement in innovative developments; closed social media group between managers of HomeNet ISPs enabling knowledge exchange and experience sharing

Figure 5. Creation of bricolage-made FTP community server

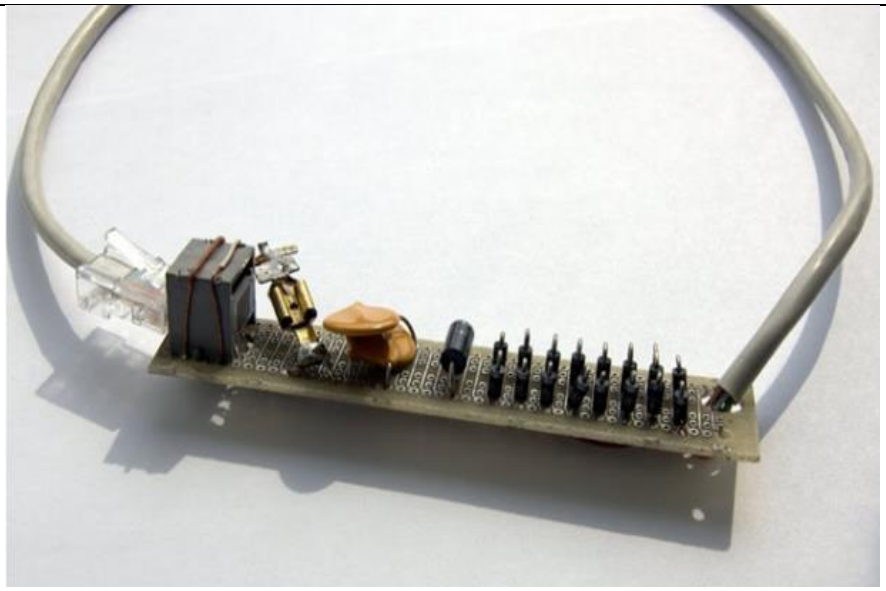


Figure 6. Examples of bricolage-made lightning rod

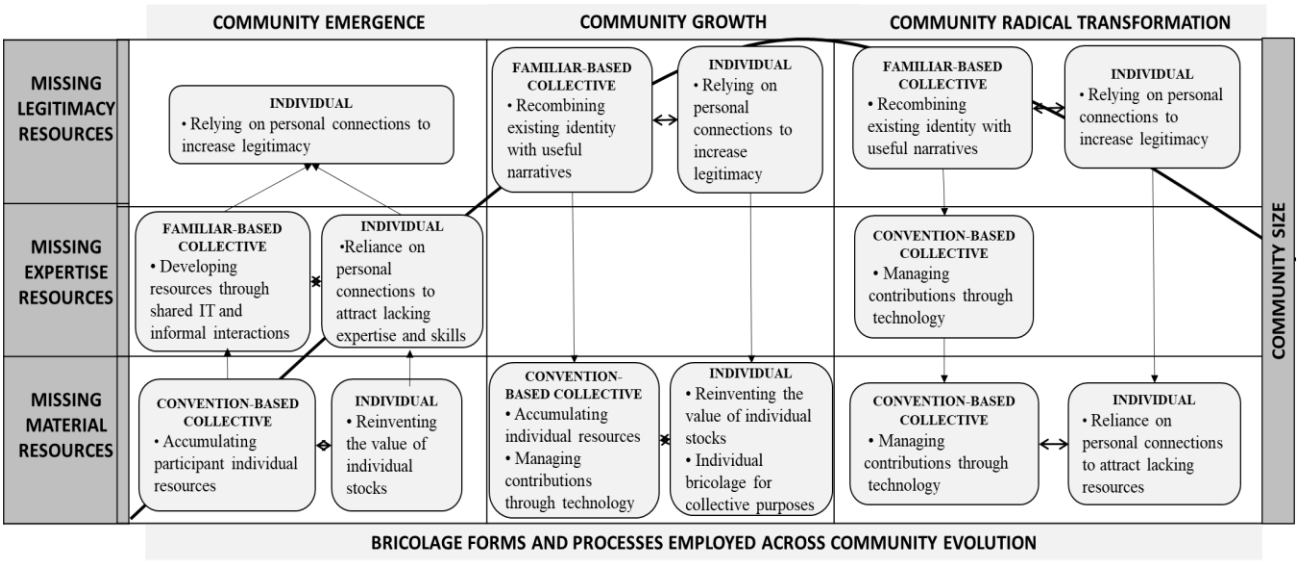


Figure 7. Model of community resource development with bricolage

Table 6. Bricolage forms stimulated by community characteristics

Specificity	Bricolage	Examples of impacts
Decentralized and informal task division	Individual bricolage	Relying on personal connections to access missing resources, increase legitimacy; reinvent the value of individual and community resources
Decentralized task allocation (self-selected roles)	Individual bricolage	Developing innovations to serve specific needs
	Convention-based collective bricolage	Accumulating individual resources through technology and contribution norms to address fluctuations in community resources
Leading intrinsic motivations	Individual bricolage	Motivating participant engagement in innovation creation with missing resources
	Familiar-based collective bricolage	Volunteering in the collective problem-solving and tasks, which increases shared values and experience
Information provision based on IT	Convention-based collective bricolage	Coordination and visualization of participant contributions
	Familiar-based collective bricolage	Providing platforms for collective problem-solving and exchanges in values and needs