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When IT Evolves Beyond Community Needs: Coevolution of Bottom-Up IT Innovation and Communities

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Abstract

This paper examines how innovative uses of IT artifacts and their repurposing to fulfill emerging or unsatisfied user needs (bottom-up innovation, BUI) develop in community settings. Based on a longitudinal analysis of "HomeNets," communities that have developed residential internet access in Belarus over a 20-year period, we illustrate that the development of community BUI is driven not only by the needs of the innovating members. Instead, community BUI development emerges from the interplay between the innovating members' community context and technology, as well as from the interplay between the BUI technology and context. We demonstrate how these dynamics trigger community BUI development that goes beyond the needs and expectations of the innovating actors and impacts community evolution and long-term survival. Based on our findings, we develop a model of community BUI development. We discuss the theoretical implications of our findings, highlighting the role of technology and context in community BUI and its processual unfolding beyond the needs and intensions of the innovating members.

Keywords: *innovative IT uses, bottom-up innovation, communities, technology, evolving, emergent, context*

1 Introduction

Innovative uses of IT artifacts and their repurposing to fulfill emerging or unsatisfied user needs (*bottom-up innovation* (BUI) hereafter) constitutes an important innovation phenomenon. Scholars of technology and innovation management have documented the role of BUI in the development of mobile technology, intranets, data infrastructures, library information systems (IS), programming codes, and enterprise systems (e.g., Bagayogo et al. 2014, Boudreau & Robey, 2005; Ciborra, 2000; Lapointe, & Bassellier, 2014; Mazmanian, Orlikowski, & Yates, 2013; Oborn, Barrett, & Davidson, 2011; Orlikowski, 2000). Despite the insights of these studies, they have mainly considered BUI development by individual users or by employees within formal organizations. In this paper we study BUI in innovation community settings (hereafter "communities"), defined

as “voluntary associations of actors lacking in a priori common organizational affiliation … but united by a shared instrumental goal [of] creating, adapting, adopting or disseminating innovations” (West & Lakhani, 2008, p. 224).

Community innovation is comparable with and often exceeding in economic and social value innovations created by traditional organizations (Benkler, Shaw, & Hill, 2015; Faraj et al., 2011; Faraj et al., 2016; O’Mahony & Lakhani, 2011). However, how members innovate with IT remains undertheorized (Benkler et al., 2015; Faraj et al., 2011; Zammuto et al., 2007). Studying community BUI provides a potential for addressing this important gap since community members often tinker, domesticate, or otherwise innovate with technology to address their local needs (Faraj, von Krogh, Monteiro, & Lakhani, 2016; Monteiro, 1998). At the same time, specificities of the community settings, such as absence of top-down authority, reliance on intrinsic and social, rather than material, incentives, common resources, and voluntary task division and allocation (Benkler, 2017; Benkler, 2002; Faraj, Jarvenpaa, & Majchrzak, 2011; Puranam et al., 2014), require re-thinking of the existing knowledge on BUI developed within organizational settings.

Furthermore, despite research that increasingly highlights a need to understand the coshaping of innovative IT user developments by various actors beyond direct IT users (e.g., Nambisan et al., 2017; Sergeeva, Huysman, Soekijad, & van den Hooff, 2017; Yoo, Henfridsson, & Lyytinen, 2010), research on BUI has more commonly focused inquiry toward a more limited set of actors (e.g., Sergeeva et al., 2017; Vieira da Cunha, 2013; Young & Leonardi, 2012). As such, how heterogenous sets of actors contribute to and shape the development of innovative IT uses is not clear. Communities provide a particularly fruitful setting for addressing the gap since their boundaries are more permeable and fluid than those of traditional organizations (e.g., Barrett, Oborn, & Orlikowski, 2016; Benkler, 2017; Faraj et al., 2011).

Research on BUI also often lacks long-term or evolutionary perspectives. This means that the current research has not been able to capture the innovative interplay between the technological artifacts and their designers and heterogenous users over time. Studying community BUI could provide valuable insights for generating processual understanding of BUI since community membership, needs, and technologies are fluid and continuously evolving (Benkler et al., 2015; Faraj et al., 2011; Faraj et al., 2016).

Addressing the above gaps, we trace BUI development in a longitudinal study of “HomeNets”—communities that developed residential internet infrastructure in Minsk, Belarus, over a 20-year period and spanned a variety of participating actors, community structures, and contextual interplay. Our findings theorize community BUI as

a continuously evolving emergent process that incorporates not only innovating member–technology interactions but also pre-BUI and post-BUI developments and is triggered by the interplay between: 1) the *context and the community*, which starts before innovative member developments and shapes the needs and frames of the potential innovators; 2) the *member(s) and the technology* in which the BUI technology emerges; and, 3) the *BUI technology and the context* in which the uses of BUI technology become reimagined by the external actor nonmembers who later join the community to develop further BUI. Based on our findings, we build a process model of BUI within community settings and discuss the theoretical and practical implications of our findings.

In the next section we review the diverse conceptualizations of BUI and discuss specificities of communities as settings for BUI. We then outline our research method, followed by the empirical analysis and findings. In the discussion we summarize the key contributions of our research for further studies of innovation communities and BUI. The paper concludes by outlining the implications of our study.

2 Background Literature

2.1 Bottom-Up IT Innovation

In this paper we conceptualize insights from studies on innovative uses of IT under the umbrella of BUI. BUI has been discussed in several interwoven, although rarely synthesized, streams of research. We summarize these in Table 1 as: 1) user-driven innovation (column 2), 2) situated and emergent IT enactments (column 3), and 3) coshaping user–IT development (column 4).[1]

Table 1. Conceptualizations of BUI

BUI streams	User-driven innovation	Situated and emergent IT enactments	Coshaping user–IT development
Description	User/social groups create new/alternative technology, including its structure and features; this stream acknowledges the role of collective social agency	Innovation emerges from situated user enactments, coshaped by user perceptions and the material properties of the technology	Innovation is emergent temporary stabilized coshaping of human and technology agency
User–technology relationships	Lead users drive IT innovations	IT artifacts as boundary conditions of users' innovative enactments	Mutually shaping ("hospitality relationship," dance of agency, imbrications)
Role of technology artifacts	Passive or not discussed	Active but led by users situated interactions	Active, symmetric to human agency apart from intentionality

[1] We also considered research on adaptations, assuming that users amend the designed embedded features of a technology in order to make it work (e.g., Alter, 2014; DeSanctis & Poole, 1994; Orlikowski & Robey, 1991). However, the stream's vision of BUI as a form of noncompliance and deviance provided limited value for understanding BUI development within community settings.

Role of context	Contextual embeddedness in collective needs and resources of user communities	Nonusers might shape the enactment of the direct technology users	Lack of contextual theorization of the interplay between users and technology
Exemplar studies	Faculty members develop novel ways of employing IT features (Bagayogo et al., 2014) The economically poor use airtime by converting cash into e-wallets for security and peer payment (Foster & Heeks, 2013; Hughes & Lonie, 2007) User innovations in Linux (von Hippel, 2005) Apache security software designed to be modifiable by users (Franke & von Hippel, 2003) User innovations in library IS (Morrison, Roberts, & von Hippel, 2000) Innovations developed by users in design of printed circuit boards (Urban & von Hippel, 1988)	Diverse and innovative uses of a corporate IS by different groups of employees (Orlikowski, 2000) Emergent uses of mobile email devices leading to tensions instead of autonomy (Mazmanian, Orlikowski, & Yates, 2013) Situated adaptation of ERP system by diverse hospital groups in different ways (Oborn et al., 2011) Emergent pattern of mobile device uses in hospitals costructured by onlookers (Sergeeva et al., 2017) Reinvention of ERP uses by employees inspired by peers and managers (Boudreau & Robey, 2005)	Open and uncontrollable ERP technology in a global industrial company led to its unplanned change and accommodation (Hanseth et al., 2001) Improvisation enabling successful implementation of ERP system in a global food and beverage company (Elbanna, 2006) Mobile data infrastructure for fire crews modified their identity and practices (Brigham & Introna, 2006) Imbrications of human and material agency in automotive design create technologies and routines which are path-dependent and driven by human perceptions (Leonardi, 2011) Materiality of a robot alters and coshapes everyday work practices of diverse pharmacist groups (Barrett, Oborn, Orlikowski, & Yates, 2012)

In the context of BUI, the three streams imply the active role of innovating IT users but offer differing explanations on the interplay between the users and technology, and the role of technology and context in BUI development (see Figure 1 and Table 1 for details). We broadly define context as "the surroundings associated with phenomena which help to illuminate that phenomena" (Cappelli & Sherer, 1991, p.56; see also Johns, 2006). Each of the three streams is discussed below.

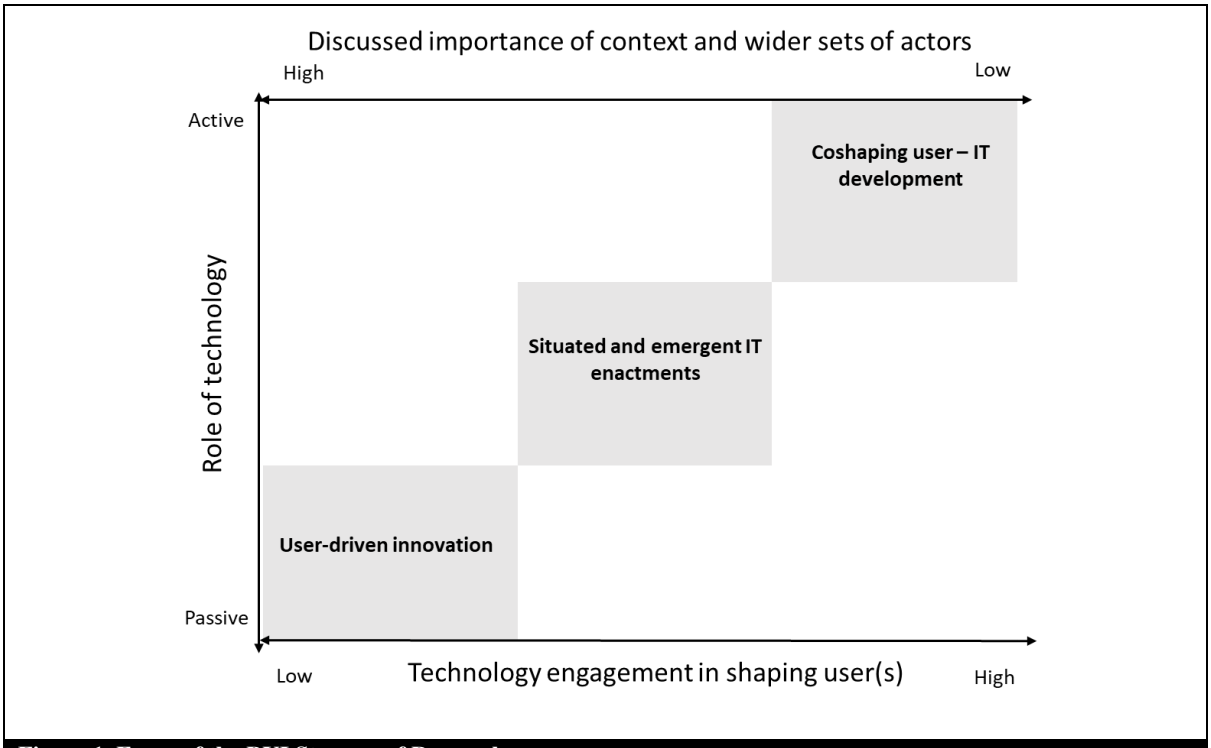

Figure 1. Focus of the BUI Streams of Research

2.2 BUI as User-Driven Innovation

This stream explains BUI as being created to satisfy users' specific needs and as an alternative to (non)existing solutions. Research in this stream assumes an active role of users and passive role of IT in BUI creation. Individuals who are able to notice alternative solutions and drive innovation development to suit their particular situation (Bagayogo et al., 2014; Faulkner & Runde, 2009; Rogers, 2003) are referred to as *lead users* (Castells, 2002; Faulkner & Runde, 2009; Oudshoorn & Pinch, 2003; von Hippel, 2005, 1986).

This stream also stresses the contextual embeddedness of BUI in community dynamics. For instance, it considers BUI to be both developed by the innovative enactments of lead users and also collectively constructed via communities of users. These communities provide sociability and support to lead users, as well as feedback testing and evaluation of the BUI, which in turn spurs further innovation (Baldwin et al., 2006; Franke & Shah, 2003; Lüthje, Herstatt, & von Hippel, 2005; Shah & Tripsas, 2007; von Hippel, 2001, 2005, 2007).

This understanding of BUI links to the research on frugal and grassroots innovations and its multiple native counterparts such as *jugaad* in Hindi, *zizhu chuanxin* in Chinese, *gambiarra* in Portuguese, and *jua kali* in Swahili (Daniels, 2010; Gupta, 2013; Prahalad, 2012; Radjou, Prabhu, & Ahuja, 2012). It supports an understanding of BUI as embedded into collective support, enabling users from marginalized groups to develop and scale up innovations to serve the unaddressed needs of a group of people (Foster & Heeks, 2013; Heeks, 2012; Heeks, Foster, & Nugroho, 2014; Hughes & Lonie, 2007). Frugal and grassroots innovations emerge as responses to severe resource limitations, and, through serendipity and experimentation, enable local users to cut the gap between the designed and the actually needed functionality (Foster & Heeks, 2013; Hughes & Lonie, 2007).

To summarize, these studies emphasize the embeddedness of BUI in the local context, collective needs, and resources of user communities, but give less attention to the particular community organizing process. These studies also fail to account for BUI that emerges out of situated and unplanned encounters with IT artifacts.

2.3 Situated and Emergent IT Enactments

Studies in this stream conceptualize BUI as being shaped by users while acknowledging the role of the materiality of the technological artifact (see Figure 1). The materiality of IT provides "boundary conditions on how we use [technology]" (Orlikowski, 2000, p. 265). Users are free to construct different meanings and enact the same technology differently "depending on the time or circumstance" (Orlikowski, 2000, p. 263), thus

creating different technologies-in-practice, which are technologies used in radically different ways in different contexts, and potentially leading to unexpected consequences (Azad & King, 2008; Mazmanian et al., 2013; Oborn et al., 2011; Yates, Orlikowski, & Okamura, 1999).

Despite acknowledging that technologies-in-practice can lead to changes in organizational structures (Leonardi, 2013; Orlikowski, 2000), studies in this stream do not explicitly discuss the active role of technological artifacts in shaping BUI. That is, whatever the materiality of technology, users can "always choose to do otherwise" (Orlikowski, 2000, p. 412) with it. In this regard, scholars have called for more attention to the materiality of technology as potentially illuminating situated innovative IT uses (e.g., Faraj & Azad, 2012; Sergeeva et al., 2017). Thus, as IT use becomes more ubiquitous and visible to a wider variety of actors, it interacts directly and indirectly with a broader set of actors. This includes coworkers, opinion leaders, and diverse groups of IT users (Boudreau & Robey, 2005; Sergeeva et al., 2017; Wang, Meister, & Gray, 2013; Young & Leonardi, 2012) who may shape the enactment of direct users (Sergeeva et al., 2017; Young & Leonardi, 2012). However, while studies in this stream acknowledge the role of context, it is treated as a backdrop or study setting, prevailingly organization-based rather than unpacked as constituted by various heterogenous actors and playing a driving role in shaping BUI development.

2.4 Coshaping Innovative Developments

This stream of research emphasizes that technology both shapes and is shaped by users. For instance, some studies suggest that users enact technology through open-ended, subtle, and recurring actions conceptualized as improvisation and bricolage (Ciborra, 1999, 2000, 2004; Lanzara, 1999). Using Ciborra's metaphor of *hospitality*, in this relationship the host (the user) not only accommodates the guest (technology) but also continuously tinkers with the inconvenient features it discovers in situ (Brigham & Introna, 2006; Ciborra, 2004, 2009; Elbanna, 2006; Hanseth et al., 2001).

Technology features and meaning are subject to continuous drift and reinvention through a blend of users' pre-determined and spontaneous actions (Ciborra, 2002; Kamoche & Cunha, 2001). Importantly, technology "also possesses its own dynamics and will begin to align the host" (Ciborra, 2004, p. 114) since the host needs to accommodate, learn, change, and react to unexpected or inconvenient technology features. As different hosts accommodate the same guest differently, so too will IT users sense different affordances that "emerge to those approaching the technology as obvious 'possibilities-to-do' this or that" (Brigham & Introna, 2006, p. 142). Thus, depending on who the users are and how they are attuned to a broader social world, their improvisation

will differ and so create different (im)possibilities of acting with IT. The latter notion suggests a potentially influential role for the actors with whom direct users relate. While the previously discussed approaches also identify the malleability of IT, this stream considers to a greater extent the properties of IT as interpretable and IT "as a toolbox for new applications" (Lindsay, 2010, p. 638).

Other studies in this stream view technology as symmetrical to humans in their agency, apart from the intentionality and interpretive flexibility of the latter (Leonardi, 2011; Pickering, 1993, 1995; Rose & Jones, 2005). Technologies exercise their agency through performativity (Pickering, 1993, 1995), "the things they do that users cannot completely or directly control" (Leonardi, 2011, p. 148), or through a "dance of agency" where technology might accommodate some of the human intentions to force technology traits to address their specific needs but resist others (Pickering, 1995).

While studies in this stream illuminate on the interplay of the user and technology, they do so largely at the expense of considering other possible influences such as a wider network of actors. Some exceptions do exist. For instance, Barrett et al. (2012) illustrate that diverse groups of pharmacists interact with diverse materialities of the same dispensing robot, and Martini et al. (2013) show that user–technology interactions are also coshaped by customers and social media platform.

Like the other two steams, studies in this stream have remained mainly limited to the context of traditional organizations. For example, while Ciborra's work emphasizes the importance of insights into broader contextual embeddedness of IT hosts, it mainly concerns corporate organizations. In this regard, Monteiro (1998) calls for incorporating Ciborra's work on hospitality in a way to account for IT domestication, that is, how technology is adopted, adapted, and continuously changed by and changing users outside traditional organizations, where IT is domesticated by nonemployee users to address their everyday needs.

To summarize, although these three BUI streams are somewhat complementary, they reveal a need for further studies on the role of technology and broader context in BUI development. Furthermore, these streams also reveal a need to study BUI outside traditional organizations since IT users become increasingly broad and heterogenous. Finally, the above BUI streams lack understanding of how the interplay between innovating IT users, technology, and context unfolds and evolves over time. As we detail in the next section, communities provide promising contexts for addressing the above gaps.

2.5 Innovation Communities as the Setting for BUI

In this paper, we focus on communities that innovate with IT and those that use IT as a means to organize and collaborate. Examples of such communities include: online open-source communities (Faraj et al., 2011; Haefliger, Monteiro, Foray, & von Krogh, 2011; von Hippel, 2001; West & Lakhani, 2008), wireless network communities (Forlano, 2008; Powell & Meinrath, 2008; van Oost, Verhaegh, & Oudshoorn, 2009), and communities innovating with both software and hardware (Foster & Heeks, 2013; van der Boor, Oliveira, & Veloso, 2014).

Like users in traditional organizations, community members often tinker, domesticate, or otherwise innovate with technology to address their local needs (Faraj et al., 2016; Monteiro, 1998). However, several important specificities distinguish community users and make their agency fundamentally heterogenous, fluid, and driven by intrinsic and social needs.

First, while employees in organizations follow contractual or proprietary relationships and top-down specified roles and routines, members in communities rely on self-selected roles and voluntary task division and allocation. They also develop, coordinate, and maintain innovations following a variety of their intrinsic and social needs as well as responding to emerging community-level needs and tensions, by taking on a variety of roles (Benkler, 2017; Faraj et al., 2011; van Oost et al., 2009; Wagner & Majchrzak, 2006).

Second, instead of hierarchical structures, community governance relies on self-organized participatory, meritocratic, and charismatic regimes, which show a tendency toward becoming more formalized and bureaucratic over time (Benkler, 2002; Benkler et al., 2015; Forlano, 2008; von Krogh, Spaeth, & Lakhani, 2003). In contrast to organizational settings, collaboration for innovation often occurs among members not known to each other, who may have diverse backgrounds (Faraj et al., 2011). Community structures also ensure different levels of access to resources and member privileges: instead of exclusive property rights, resources and innovative outcomes within communities are typically governed by open-commons or common property rights (Benkler, 2017; Benkler et al., 2015; Puranam et al., 2014). Diverse community structures, in particular, provide diverse backgrounds for member involvement and coordination of innovation developments. For example, while core members mobilize community resources for their initiatives more easily, peripheral members tend to explore innovative opportunities that the core members ignore (Dahlander & Frederiksen, 2012; Lakhani, 2006). Recent thinking suggests that even periphery members can contribute ideas that are highly valued (Safadi et al., 2020).

Third, communities are fundamentally fluid in nature since their boundaries, norms, participants, artifacts, interactions, and foci continually change over time, enabling valuable knowledge exchange and generation (Faraj et al., 2011).

Building on the above specificities, some studies explain community innovation as shaped predominately by members who create, modify, and unidirectionally manage technology to satisfy their needs (e.g., Dahlander & Frederiksen, 2012; von Hippel, 2001, 2005). Other studies have argued that the capacity of individuals to organize in communities and create and leverage innovations is significantly boosted by the low cost and widespread access of IT (Benkler, 2002; Benkler & Nissenbaum, 2006; Franke & von Hippel, 2003; von Krogh et al., 2003). In this regard, some studies have called for more detailed attention on the role of technology, illustrating that IT might also be used to channel and control the innovative contributions of selected experts (Halfaker, Kittur, & Riedl, 2011; Shaikh & Vaast, 2016).

Yet, other research has discussed specific IT features that enable community innovations, such as the modularity and granularity of IT (e.g., Benkler, 2002; Benkler & Nissenbaum, 2006), as well as IT reviewability (enabling the community content to be viewed from multiple perspectives; West & O'Mahony, 2008), recombinability (enabling mixing and building on each other contributions; Jarvenpaa & Lang, 2011), and experimentation (encouraging novel ideas; Hienerth & Lettl, 2011). However, despite substantial attention being paid to IT features enabling community innovation, our knowledge of community innovation as shaped by the interplay between members and the materiality of technology has remained undertheorized (Faraj et al., 2016; Faraj et al., 2011; Zammuto et al., 2007), which limits our understanding of how exactly technology supports and enables members in creating and self-organizing for innovations.

Furthermore, the interplay between community technology and contexts has remained ambiguous. Previous studies have discussed this interplay by focusing on IT-enabled community boundary permeability. On the one hand, technology makes community boundaries particularly flexible, which enables the community innovation to scale up (Benkler, 2002; Butler, Bateman, Gray, & Diamant, 2014; Lindsay, 2010; von Hippel, 2005) and become available for cooperation and contribution from a potentially unbounded set of actors from diverse geographical locations, time zones, and backgrounds (Benkler, 2002; Benkler et al., 2015). Now it is not only community members but also organizations and diverse stakeholders who can participate in community innovations (e.g., Barrett et al., 2016; O'Mahony and Bechky, 2008; von Hippel and von Krogh, 2006). In this

way, IT augments the agency of members with extended knowledge-recombination, anytime/anywhere access, and engagement (Barrett et al., 2016; El Sawy, Malhotra, Park, & Pavlou, 2010; Faraj et al., 2016).

At the same time, community boundaries need to be constantly negotiated with external actors (Jarvenpaa & Lang, 2011). Extensive openness can undermine community innovations (Barrett et al., 2016; Shaikh & Vaast, 2016). Ambiguity over the role of IT-enabled boundary permeability in community innovations leaves open the question of exactly how, and what kinds of, contextual impact can contribute to community innovation.

In this paper, we address the above gaps by studying how BUI in communities develops through the interplay between the heterogenous and fluid community agency, technology, and evolving social context.

3 Research Methodology

3.1 Research Setting

We examine how HomeNet communities in Minsk, Belarus, developed BUI technologies, services, and internet infrastructures. Created and used by residents, such communities were common in Eastern Europe, Russia, Ukraine, and Poland in the 1990s and early 2000s. With some exceptions (Levina & Vaast, 2008), Eastern European countries are not frequently the site for IS studies.

In 2016, Belarus was considered one of the four outliers globally (along with South Korea, Estonia, and Bahrain) that significantly outperformed their expected positionings in IT and internet access, based on their gross national income per capita (ITU, 2016). By contrast, though, the country's level of internet access was underdeveloped in the 1990s. Owing to complex conditions in the residential internet market, such as the most prolonged state monopoly in Eastern Europe, high internet prices for citizens, and low margins of private internet service providers, residents in Minsk engaged in IT tinkering and innovations to create community-developed infrastructures that connected about 90% of all residential computers to the internet between the 1990s and 2000s (Scherban, 2010). Our analysis thus covers a 20-year period, starting from 1994, at which time several small groups of enthusiasts were already active.

3.2 Data Sources

Our study used multiple qualitative data sources—in-depth field interviews and observations combined with detailed documentary, web-based, and archival data—to capture the evolution of our phenomenon over time and

provide a rich and reliable research result. Table 2 summarizes the three data sources and their volumes, collection details, and objectives.

Table 2. Summary of Data Collection

Data	Volume	Details	Objectives
Interviews (number)	97	Semi-structured and open-ended 89 face-to-face interviews 8 interviews conducted by phone/Skype, supplemented with email exchanges to follow up and clarify comments	Insight into the emergence, structure, and organization of HomeNets, the technology use, innovative developments as well as the dynamics and impacts of the external environment
Observation (hours)	17	Conducted during Phase 1 Enhanced with in-depth notes and, in some cases, photos to help reconstruct insights immediately afterwards	Insight into situated uses of technologies and the work of administrators (e.g., renovations of network-infrastructure, experimentation with technology, informal gatherings of administrators and users, and routines of using technology)
Secondary data (documents, photos, videos, websites)	300+	HomeNet financial and accounting records; photos and videos on creation, development, maintenance, and repair works; social activities (e.g., discussions and activities of offline meeting, events organized for and by members); HomeNet statutes; technology connection maps; HomeNet and ISP websites and forum discussions; related ISP and government policies; government laws and initiatives; books and research publications on the development of the residential internet sector in Belarus between 1994 and 2016	Insight into community management and operation (e.g., meeting minutes, strategy documents, photos, and videos of HomeNet practices) Insight into the context and impacts of external actors (e.g., media discourse, ISP policies, government laws)

Data collection was carried out between 2010 and 2016 and was collected in two phases: Phase 1 comprised the primary data collection, carried out as a part of a PhD dissertation; in Phase 2 we deepened our understanding of HomeNet context and the role and dynamics of external actors, which the data analysis suggested was particularly important.

Interviews were the primary form of data collection. They spanned 35 different HomeNet sites across all urban areas of Minsk, covered all HomeNet sizes and development periods, and were undertaken with a variety of actors involved or influencing HomeNet BUI development. Interviews were guided first by a semi-structured set of questions (Myers & Newman, 2007), with additional questions tailored to the informant's experience and profile (see Appendix A for interview questions). The interviews with developers, administrators, and users focused on the emergence, structure, and organization of HomeNets and the BUI community, as well as the use of HomeNets, situated practices, stakeholders, and pressures. Interviews with ISP managers focused on their collaboration with HomeNets and on details of residential internet access and related services that the ISPs provided and developed. Table 3 provides details the number of interviews undertaken with each actor.

	Table 3. Interviewee Details			
	Phase 1 details	**No.**	**Phase 2 details**	**No.**
HomeNet communities	HomeNet administrators *(founders who created, maintained, and developed HomeNets)*	37	HomeNet administrators *(founding enthusiasts who created, maintained, and developed HomeNets)*	5
	HomeNet users	22	HomeNet ISPs *(founding directors of all seven major ISPs that developed out of HomeNets)*	7
	HomeNet ISPs *(founding directors and managers that transitioned HomeNets into commercial entities)*	4		
Other stakeholders	ISPs *(project, sales, and strategy managers)*	10	Private ISPs *(CEOs, marketing and operational directors)*	4
	State ISP Beltelecom *(network engineer and sales manager)*	2	State Beltelecom ISP *(a system administrator and developers of Beltelecom's billing services for residential dial-up and ADSL (ByFly) services)*	2
			Experts *(UN Development Programme consultant on internet/ICT4D in Belarus; founder of e-belarus.org; popular blogger on internet providers in Minsk) (http://www.interminsk.com); founder of a national HomeNet website (Homenet.tut.by)*	4
		75		22
	Total number of interviews: 97			

3.3 Data Analysis

In total, over 600 pages of qualitative data were analyzed. Our first step was to organize the data to reconstruct a detailed understanding of the emergence and evolution of BUI in HomeNets. Figure 2 details these insights in a process chart (Langley, 2009), illustrating HomeNet evolution across four key phases (egalitarian, meritocratic, core–periphery, and entrepreneurial core structures), as well as community interactions with a wide ecosystem including residents, commercial and state ISPs, and the state.

Our second step was to discover the relationships in our data through a grounded theory approach (Glaser & Strauss, 1967; Suddaby, 2006; Urquhart & Fernández, 2016) and following the four stages suggested by Glaser and Strauss (1967): 1) comparing incidents applicable to each category; 2) integrating categories and their properties; 3) delimiting the theory; and 4) writing the theory.

In the first two stages, we coded broadly to encompass several theoretical concepts (Volkoff, Strong, & Elmes, 2007) relevant to understanding how communities develop innovative uses of IT. At the same time, we could not avoid influences from existing theories while collecting and analyzing data (Suddaby, 2006; Urquhart, 2016). Such theories (e.g., on BUI and community innovations) were helpful in stimulating the initial development of categories (Glaser & Strauss, 1967) but could not fully inform our analysis, which motivated further development of theoretically significant observations and concepts (see Figure 3).

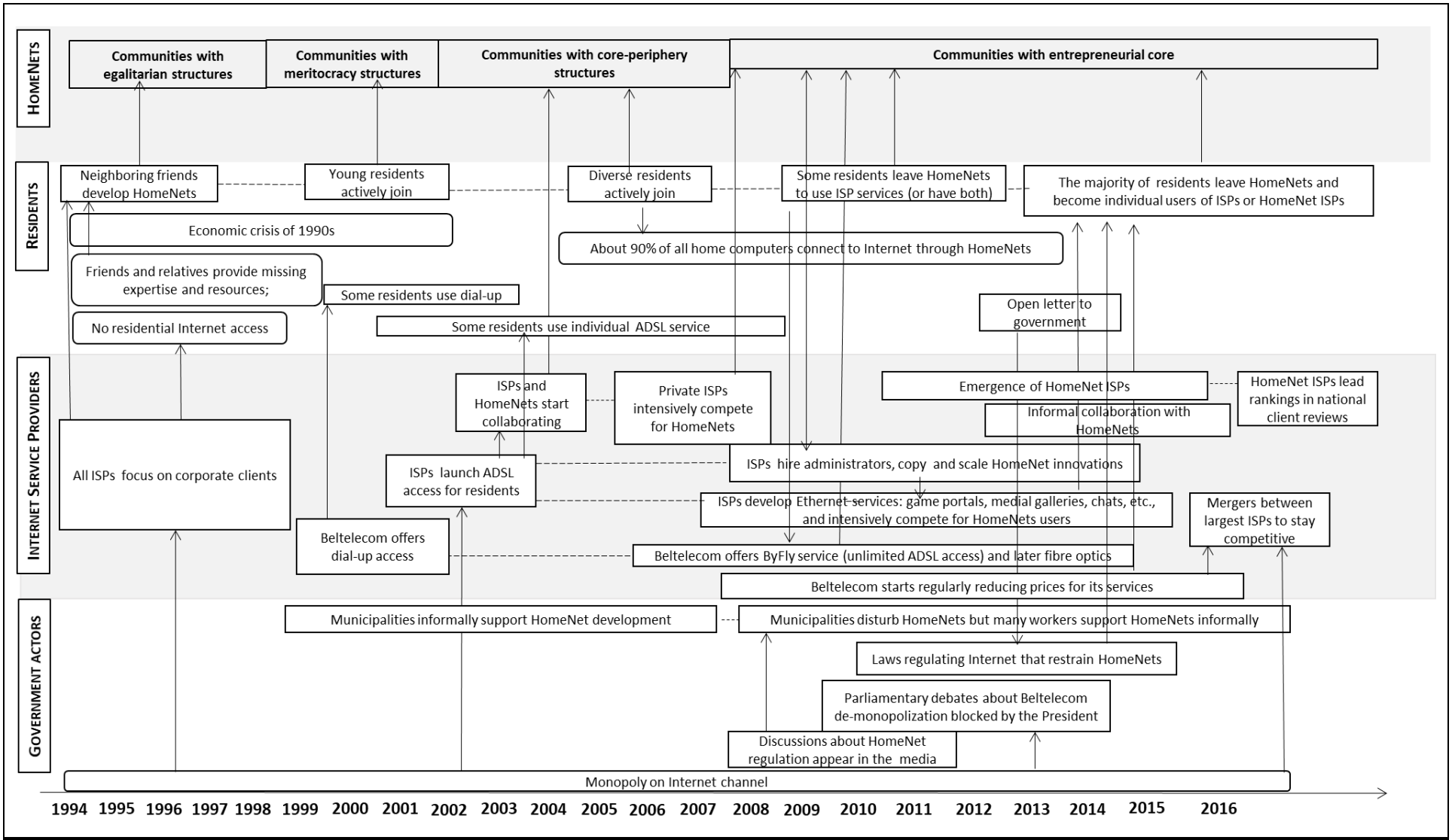

Figure 2. Process Chart of the Evolution of HomeNets Within Their Ecosystem

In the first stage, each researcher coded a sample of data using multiple emergent categories while simultaneously comparing the incidents across interview transcripts with different actors (Glaser & Strauss, 1967). Following discussion and negotiation of the codes (Glaser & Strauss, 1967), a codebook and term table were created and used by the field researcher to code the remaining transcripts.

In the following stage we integrated categories and their properties (Glaser & Strauss, 1967, p. 108), discovering variations and characteristics for each category, such as specificities of diverse community structures and BUI stages. In negotiating the findings as authors, our different research traditions enabled us to challenge each other's ideas and underlying assumptions, ensuring that the analysis remained grounded in the data (Volkoff et al., 2007). For example, our analysis revealed that the properties of multiple categories were significantly influenced by the context and its dynamics (Johns, 2006). Based on this, we conducted a second round of data collection (detailed above in Section 3.2), focused on the role of context on the development of community BUI. This helped us to identify events and factors that contributed to changes in the trajectory of BUI evolution and led to the development of theoretical constructs such as "nonmembers reimagining BUI uses." Our list of categories expanded in diversity and scope until we reached a point of theoretical saturation, which is when "no additional data are being found whereby the sociologist can develop properties of the category" (Glaser & Strauss, 1967, p. 61).

In the final two stages of the analysis, we reduced the original list to a smaller number of higher-level concepts based on "underlying uniformities" (Glaser & Strauss, 1967, p. 110), which we summarize at Figure 3. This enabled us to notice that BUI development followed a similar pattern across different community structures and to work out a conceptual model (Figure 4) applicable to a wide range of situations (Glaser & Strauss, 1967).

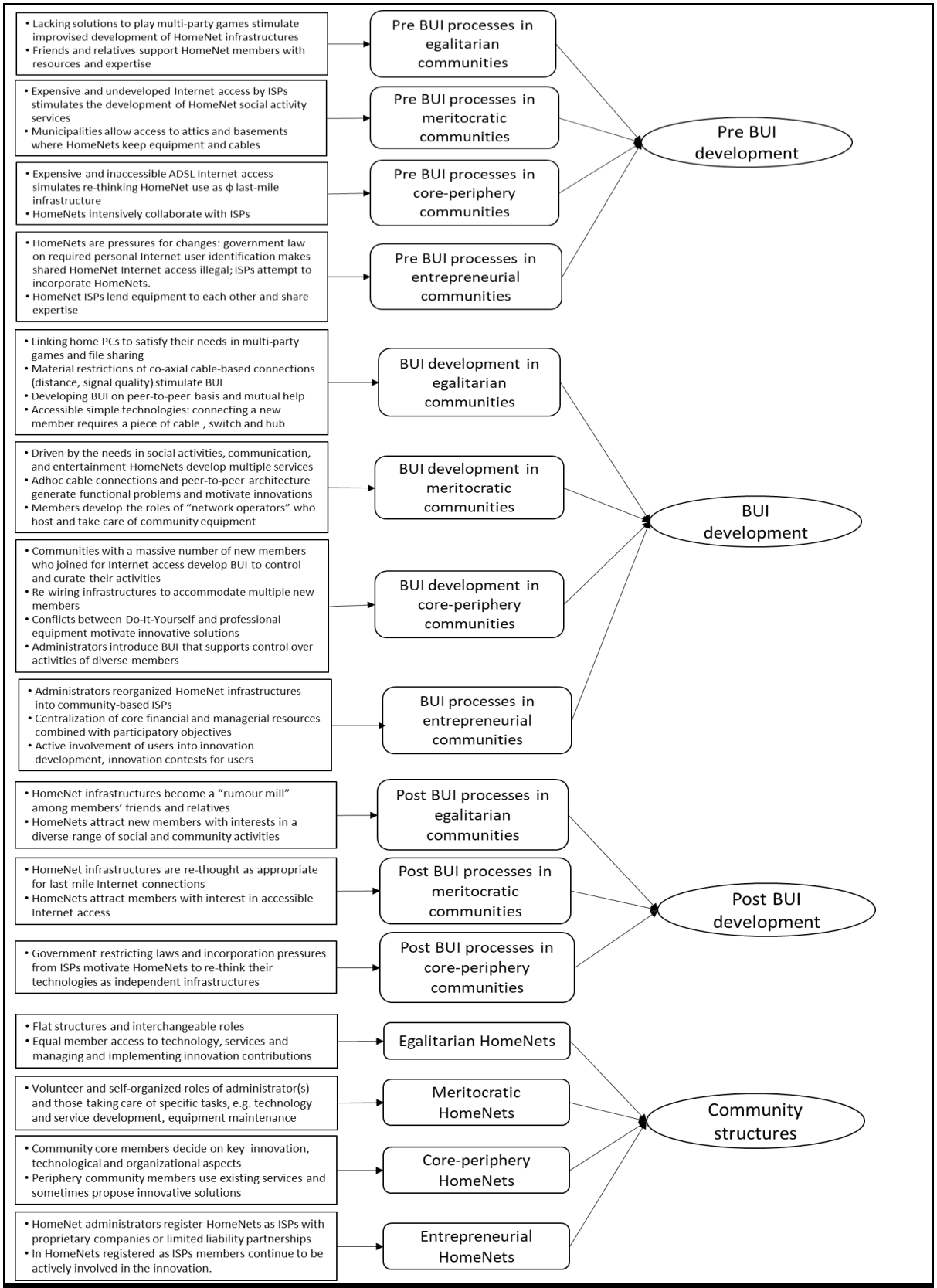

Figure 3. Data Analysis and Theoretical Constructs

4 Findings

The longitudinal nature of our study allows us to generate insights into the common patterns of BUI development across diverse and evolving community structures. Our findings reveal that innovative member–technology enactments are important but not fully constitutive of the BUI dynamics within communities. Instead, community BUI unfolds through the interplay between the context, community, and technology. We call these processes pre-BUI development, BUI development, and post-BUI development and outline how they unfolded across diverse phases of HomeNet evolution in Figure 4.

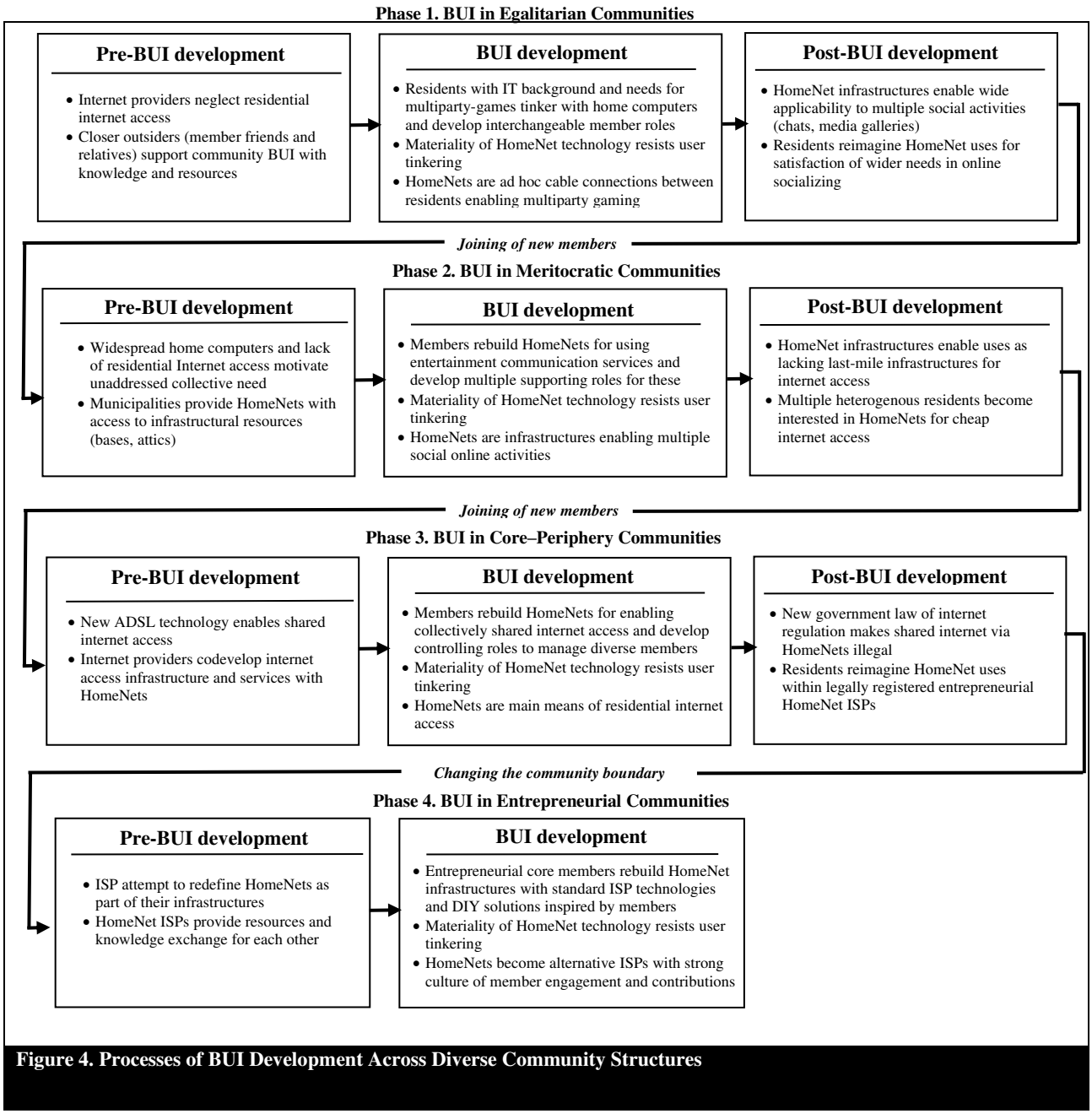

Figure 4. Processes of BUI Development Across Diverse Community Structures

As Figure 4 illustrates, during the pre-BUI development process, actors external to the community shape the emergence of needs driving the innovating members; the development of community BUI is also supported by resources and knowledge from some external actors. During the process of BUI development, community members innovatively enact technology, self-organize roles to enable the innovation, and encounter resistance from the materiality of technology to their innovative intentions. As Figure 4 illustrates, after members create BUI that satisfies their needs, the development of community BUI does not stop. Instead, it proceeds with the post-BUI development process, where the BUI technology attracts the attention of nonmembers, who reimagine its possible uses for addressing their own needs and join the community or otherwise affect their boundaries. The rest of the section discusses the unfolding of the above BUI processes in detail across diverse phases of HomeNet development.

4.1 BUI in Egalitarian Communities (1994-1998)

Between 1994 and 1998, small groups of young neighborhood friends with an interest in digital technology aimed to satisfy their need to play multiplayer games and share files. The lack of accessible residential internet access and the high cost of cybercafes motivated them to link their home computers via coaxial cables and use Windows OS to set up improvised network connections for gaming and file sharing. In creating such HomeNets, residents reimagined the conventional use of their home computers by relying on previously unused technology features (e.g., Windows network protocols) and combining these with new technologies (e.g., cables, network cards, hubs). The process was emergent and often relied on bricolage such as with old cables from relatives and friends:

> *It all started when we came up with the idea of playing games together.* ***We didn't know how computer networks worked but decided to sort it out. So we shared some cable, some money, and constructed "something."***[2] (HomeNet developer, interviewee 17)

Technology supported such innovative enactments, with its flexibility and malleability, but also resisted some developments, which further stimulated BUI developments in emergent ways. For example, for the signal to transmit, a typical coaxial cable allowed a distance of 100 meters between members' dwellings. When a resident living further away wanted to join, the community had to improvise new technologies, for example by constructing a DIY cable signal booster, using cables with extended signal capacities, or using two attuned TV

[2] In quotes, bold indicates emphasis added.

satellite antennas to transmit the signal by air). Some cables and equipment were particularly sensitive to weather conditions and underperformed or failed during snow and storms, which motivated members to develop DIY protective devices (e.g., lightning rods) and covering boxes, and to find solutions using nontypical technologies. For example, problems with air connections often caused HomeNets to use P-296 cable with signal capacity up to 500m (originally used by the Soviet/Russian army to communicate in field operations), instead of using a typical twisted pair cable with a signal capacity up to 100m. Figure 5a (dated 1999) shows HomeNet cable connections linking members in the same building, while Figure 5b shows the process of constructing a cable connection between residential buildings.

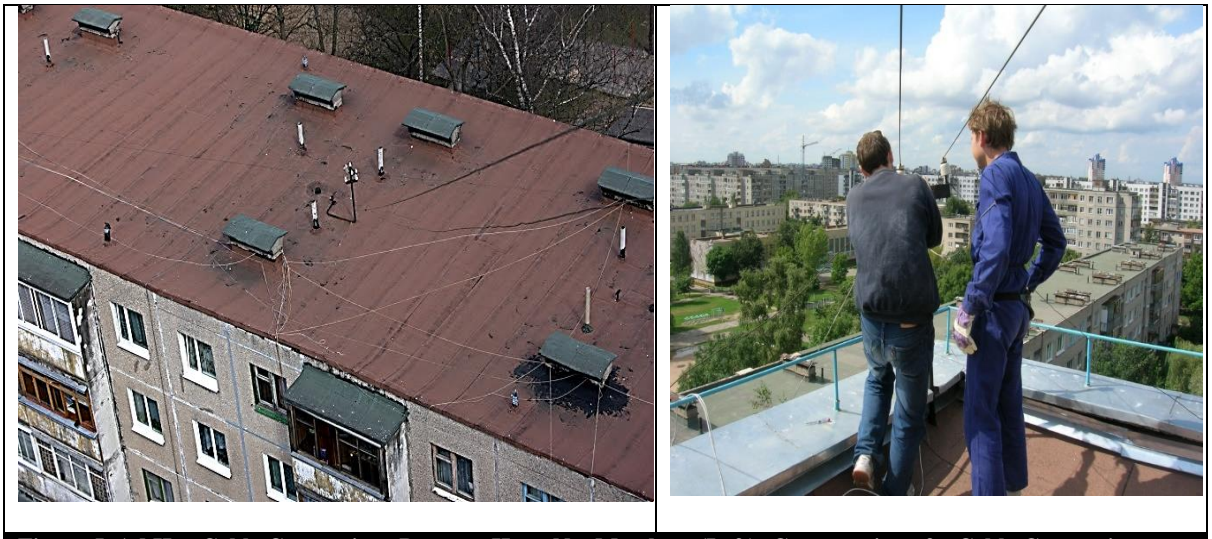

Figure 5. Ad Hoc Cable Connections Between HomeNet Members (Left); Construction of a Cable Connection (Right)

Importantly, friends and relatives of HomeNet members contributed to BUI development by assisting the choices of technological artifacts for HomeNet construction and providing support with how technologies were used and constructed (e.g., by sharing their know-how and expertise; lending the necessary construction equipment; and supporting developers with some initial funding):

> *[Our] parents …* ***helped to find a drill to make holes in concrete slabs where cables couldn't be linked through communication channels.*** *Understandably, our neighbors wondered why we were drilling. … Some got interested; others called the Militsiya [local police]. Naturally, at this early stage,* ***our parents were nearby and helped a lot in sorting out these problems***. (HomeNet developer, interviewee 20)

The new technologies favored certain types of member communication and coordination, thus contributing to member self-organization into certain structures and roles. At this stage, HomeNets used simple chats with no

administrative rights or server need (e.g., embedded Windows Messenger, MyChat) and relied on peer-to-peer network architecture, which made all participants equipotent for contributions and modifications. This relative technical simplicity supported the development of an egalitarian structure and interchangeable roles. For example, the connection of new members was undertaken collectively by existing members. The egalitarian principles also applied to funding (sharing the costs) and repair works, where the members on whose side the equipment broke down were responsible for fixing it:

> ***Everyone was equal … we were simply consulting each other***. (interviewee 4, original founder)
>
> ***Everyone contributed in the way they wanted to***. (interviewee 19, user)

After members developed HomeNets for gaming and file sharing, these in turn influenced the community in ways unexpected by the original creators. HomeNet infrastructure became a topic in the "rumor mill" of the members' friends and relatives. Linking such members led to change in the community technology and organizing:

> *[After new members joined] it became a different system, a more complex level of network construction and … technically more difficult.* (interviewee 17)

The new members had interests well beyond gaming and were looking for ways to satisfy their needs using highly permeable and flexible HomeNet technologies. This led to the emergence of a new collective need and stimulated a new wave of BUI development.

4.2 BUI in Meritocratic Communities (1999-2001)

During this phase HomeNets' boundaries and membership grew significantly, ranging from several dozen to several hundred members. Members innovatively reimagined the uses of existing HomeNet infrastructures to address the absence of residential internet access (at the time home computers were on the rise) and serve their novel collective needs in social activities, member communication, and entertainment. This was done through the development of such BUI as network radio, interactive member maps, and community servers.

Technology also stimulated BUI development. For example, existing peer-to-peer network architecture happened to be problematic when several members simultaneously viewed the same files shared by another member. This stimulated innovation such as the development of servers where members pooled interesting content (films, music, books, etc.) from their computers, allowing users to stream and copy shared content from members' PCs. Likewise, community chats evolved from simple and nonadministered forms to more advanced

virtual chatrooms, with the possibility of diverse administrative roles and member communication and exchanges stored on servers. Finally, the quality of ad hoc network connections became unreliable as the number of users grew (especially for periphery nodes) and these had to be rewired into a new more structured typology. This led to innovations such as underground and Wi-Fi cable connections and DIY routers, allowing the signal to pass over long chains.

The development and maintenance of new BUI stimulated the emergence of new roles: "innovators"; "network operators," who hosted community servers, switches, and so on at their apartments; "repairers," who constructed networks, linked up new members, and undertook repair work; and "content developers," responsible for adding new videos, music, or games to the community server. The increased technical complexity also implied a need for an administrator who would be responsible for technical and organizational maintenance and the development of HomeNets:

> *It was similar to having a child. Some people have a daughter or a son, and* ***I had my network to bring up****. It was a part of our youthful ambitions: You know,* ***when you want to change the world, create something important for people, and become a famous and respected person****.* (HomeNet administrator, interviewee 24)

Over time, important roles were formalized in HomeNet statutes, which also articulated HomeNets' mission and goals, technologies, and codes of conduct and were voted for by members via community chats and at regular offline community gatherings (e.g., monthly/bimonthly "network tea/beer" meetings), where members also decided on other important questions (e.g., monthly fees or mergers between HomeNets). Notably, members would not just develop and implement their innovations directly (as they had done in egalitarian structures) but would first approach the administrator or/and discuss their innovations at community gatherings:

> ***People usually came to me during offline meetings and proposed things and ideas.*** *We then tested these services on the users' computers and, if everything was fine, integrated them into the network.* (HomeNet administrator, interviewee 57)

As communities grew in scale, connecting numerous multistory buildings, they needed approval from their local municipalities. The latter impacted community BUI development since they decided on and granted the access to basements, rooftops, and communication channels within buildings necessary for linking up the many and various new members.

Furthermore, looking for further ways to satisfy members' need for entertainment and socializing, some administrators developed the (in their understanding at the time) minor innovative idea of using the existing HomeNet infrastructures as a shared last-mile infrastructure for the ADSL-based internet access that some ISPs were starting to offer. This minor innovation received unexpected interest from noncommunity residents, who redefined the dominant need from a close-knit community BUI to one that enabled internet access. The joining of these new users altered HomeNets' boundaries and membership to an unprecedented scale and diversity. New users, coming from a range of age groups, interests, IT skills, and professions (e.g., students, whole families, homemakers, retired people, freelancers, and businesses housed in rented apartments), sought to reinterpret the value and uses of HomeNets as infrastructures for affordable internet access.

4.3 BUI in Core–Periphery Communities (2002-2007)

The ADLS-enabled opportunity for high-quality, affordable internet offered by HomeNet–ISP collaboration led to the "exponential growth" of HomeNets. During this time, a narrative emerged that a "computer without a HomeNet is like a TV without an antenna" (HomeNet user, interviewee 23) and media reported that around 90% of all home computers in Minsk were connected to the internet through HomeNets (Scherban, 2010). Many administrators became overrun with interest from residents who wanted to join HomeNets:

> *To put it in numbers: an owner of a personal modem would pay 60,000 Belarusian rubles per month [USD 28] on average, while the most expensive package for a HomeNet member would cost 40,000 rubles [USD 18]. For an average HomeNet internet user, the prices were really low—about 5,000-10,000 rubles [USD 2.3-4.7 at 2005 exchange rate] …* ***we had a crowd [of new users] waiting for us***. (HomeNet administrator, interviewee 58)

The existing HomeNet technologies accommodated the mass joining of new members but also resisted this in some notable ways, motivating further BUI. For example, the existing network architectures often could not support connections for hundreds or thousands of PCs linked with different cables and a mix of DIY and professional equipment, which generated signal loss and unexpected disconnections:

> *A guy called Pavel happened to be the central node in our network after it boosted. For some reason, when he turned on his computer, one part of the network randomly disconnected from another. … So, everyone rushed to finish their downloads, file sharing, etc, before Pavel would come back from work.* (interviewee 19, user)

Such emergent constraints forced further innovations in rewiring network architectures, replacing unstable "by air" connections with underground or fiber-optic cables between busy nodes, and, in some cases, in more ad hoc and DIY equipment attempting to fix the problems. In a similar vein, BUI in reconstructing media galleries and file-search programs was developed as a response to member practices of uploading books, films, music, and so on from affordable yet still costly and limited internet access onto the community server, which led to anarchic databases. The internet that was available stimulated BUI by enabling the sharing of knowledge on innovative solutions developed in other HomeNets in Minsk, as well as other countries (such as http://www.compdoc.ru/network/local/lanbuild, an online manual for building HomeNets, with detailed innovative tips). Unexpectedly, HomeNet infrastructures were discovered to provide members with the unique possibility to switch between different offers (e.g., using one ISP for its cost or special bonus time and another for its speed) simply by switching a cable.

Importantly, during this stage the community self-organized into a hierarchical structure of "core" members (administrators, their main assistants, and users who built innovations on the HomeNets) and "periphery" members (users who consumed it as a commercial service with little interest in the community or BUI). In contrast to the previous stage, the "core" members introduced control mechanisms to guide other members. Prior to community votes on important changes (i.e., the introduction of new equipment, ISPs, or connections with neighboring HomeNets), core members would meet together "to decide what is right and then explain it to others" (administrator, interviewee 38).

Administrators introduced BUI that would enable more control over the highly diverse membership. For instance, since HomeNets provided clear identification on participating members, administrators introduced chats and member-developed code for server manipulations (e.g., (dis)abling member access and content manipulations in cases of inappropriate behavior or nonpayment). A common BUI was also programming switches as internet routers to enable internet traffic control and disconnection of individual members. Administrators also started developing and installing IT that would encourage sharing between members:

> *Initially, file sharing was based on BIOS and TP protocols. These were based on the principle of "take whatever you wish." Later, however, we introduced a DC protocol [peer-to-peer file sharing] so as to stimulate the file-exchange dynamics in the network:* ***in order to download a file, a user needed to share a file in return***. (HomeNet administrator, interviewee 66)

By 2003 almost all ISPs collaborated with HomeNets, making community internet the main form of internet access in Minsk and stimulating HomeNet BUI development. For example, ISPs contributed to the development of shared internet access by offering free modems and special low tariffs for communities with 10-30 members and a 10% discount for administrators. HomeNets and ISPs also jointly developed services for individual payment cards and traffic control for HomeNet users, and shared the costs and works of constructing the fiber broadband infrastructure linking HomeNets and ISPs.

By enabling affordable and shared residential internet access, HomeNet infrastructures became visible to external actors, who started to take notice because it encroached on their interests. As a local newspaper stated, "HomeNet webs [cable connections] has spanned the whole city." First, the state-owned ISP, Beltelecom, started a campaign against HomeNet communities and lobbied the government to force municipalities to cut off "illegal" networks. The company also occasionally sent its workers to cut off HomeNet cable connections in strategically important districts. Second, in the run-up to the 2010 presidential elections, the government started tightening control over internet use and infrastructure. In early 2010, the government introduced Decree of the President No. 60. With effect from July 1, 2010, this law required all ISPs to identify—and keep records on—individual users of the internet. In this new system, community access to the internet was outside the law. Finally, despite their previous long-lasting collaborating with HomeNets, ISPs used the Decree to attempt to take over HomeNet infrastructures. Presenting their intention as "protection," ISPs proposed bonuses to members to become individual ISP clients and financial incentives for administrators to transfer ownership and control of the infrastructures to them.

HomeNets reacted to these pressures in three different ways. Some HomeNets were assimilated with "help" from ISPs to mitigate the potential legal repercussions associated with being unregistered internet users. After assimilation, former members ceased involvement in BUI and became ordinary ISP customers. Other HomeNet communities went "underground," maintaining the basic structure of their agency (administrators and regular users) and continuing internet connectivity through unofficial collaboration with ISPs. Despite this, no BUI community development took place in such HomeNets and they eventually dissolved after a few years. Yet, other communities developed into successful community ISPs by focusing on accommodating the collective needs of those members who sought not only affordable internet but also community activities and contributions. We follow their BUI development below.

4.4 Entrepreneurial Communities (2008-2016)

Some communities responded to the new regulatory environment by legally redefining themselves as a commercial ISP—a "HomeNet ISP."

> *[When] the government started a war against illegal HomeNets we took a decision to build a company that would unite several independent, amateur (but large) networks and led them to a new level of development.* (Onenet website, HomeNet ISP[3])

> *We had to make a decision: either making [HomeNet administration] our profession and invest in its legalizing and further development, or not bothering with it any more. We decided to give it a try.* (Director of a HomeNet ISP, interviewee 94)

Administrators reorganized their HomeNets into community-based ISP start-ups, securing investment and becoming founders, senior managers, and specialists.

> ***Eventually, a team of core members emerged … each with different expertise****. [Administrator] was a technical gig, I was pretty strong in management … another former administrator knew well how to write project documentation to legalize. … Another guy was keen on organizing marketing. … We managed to find an investor and started building an ISP.* (HomeNet ISP director, interviewee 88)

To meet the official requirements for registration as an ISP, some existing HomeNet technologies had to be modified, removing the principal ad hoc elements and rewiring the architecture so that it became more centralized and standardized. Such changes toward centralization consolidated control and key resources in the hands of the entrepreneurial core members. At the same time, other community technologies, such as intranet work chats and comments, provided the backbone to communicate with other members, and developed in the direction approved and suggested by members.

Serving the collective needs of members who needed not only affordable internet but also strong community services, HomeNet ISPs strongly relied on innovative IT developments by members to save on otherwise expensive proprietary corporate solutions. As a HomeNet ISP director stated:

> *We do not buy expensive hardware with embedded code firmware. Instead,* ***we buy a standard server and embed our home-made code into it****, thus reducing investments in many cases.*

[3] http://onenet.by/o-onenet/

Members also proposed innovative developments unique to the market of ISPs, such as enhancing HomeNet infrastructures with CCTV cameras for residential security. They also actively developed BUI that served and strengthened community engagement, such as a billing system that would return money to members who shared their content resources with others. As summarized on a webpage of a HomeNet ISP, the community heritage and contributions remain strong:

> ***The absolute number of the company services and resources are created by its users***. *... The company name UNET ...* ***is an acronym playing around "United [Home] Networks" … and "You-network."*** *...* ***Since its emergence hundreds of people contributed to the network and company development*** *... and continue boosting this unique project.* (UNET company website[4])

HomeNet directors continued to rely on HomeNet infrastructure support and nurture a strong community culture by organizing regular member competitions, meetings, and innovation contests, just like HomeNets with meritocratic structures did. As a result, some HomeNet ISPs managed to develop into relatively small (about 7,000-20,000 users) but successful ISPs according to national rankings (see http://providers.by/rating).

HomeNet ISPs also actively lobbied their interests in the national ISP association and intensively supported each other when developing BUI. For example, HomeNet ISPs offered hard-to-source equipment to each other. Directors of diverse HomeNet ISPs and core developers had a vibrant chat room where they exchanged know-how and potentially relevant legal and commercial information. As a HomeNet ISP stated in the interview:

> *We are not competitors. Historically and also strategically we operate in different areas of the city but, most importantly, we know that we can't survive against Beltelecom and other [ISPs] if we compete between ourselves.*

5 Discussion and Implications

Our findings illustrate that BUI development within communities unfolds through the long-term interplay between members, technology, and context and evolves beyond the needs, intentions, and envisioned paths. Based on our findings, we develop a model of BUI development within community settings and discuss its theoretical and practical implications as well as areas for future research.

5.1 Model of BUI Development Within Innovation Communities

[4] https://www.unet.by/about/

Our findings illustrate that community BUI develops through three repeating interrelated processes: pre-BUI development, BUI development, and post-BUI development. Each processes is coshaped by different driving dynamics of interplay between the innovating members, technology, and context (see Figure 6).

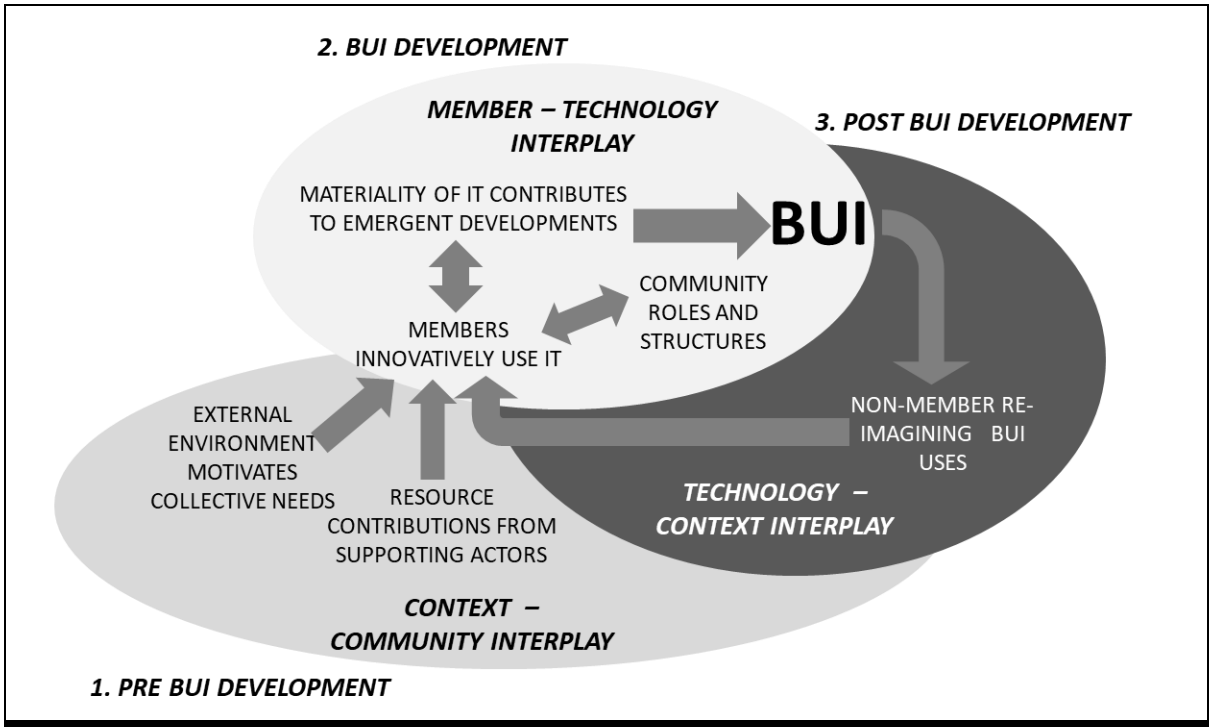

Figure 6. Model of BUI Development Within Innovation Communities

As Figure 6 illustrates, the pre-BUI development process is driven by the interplay between context and community, whereby the external environment stimulates IT users to join communities to collectively problem-solve to satisfy their social and endogenous needs, such as a lack of specific services and activities (Phases 1 and 2) or internet access (Phase 3) or the inability to continue to use IT owing to new legislative or institutional pressures (Phase 4). The importance of such contextual inputs is that they not only motivate potential members to join the community for innovation but also directly or indirectly coshape the nature of the community participants and their needs. Furthermore, external actors might contribute various necessary resources and knowledge for community BUI development. Such supporting actors evolved alongside the community development and included, in particular, friends and relatives with the necessary know-how and resources, municipalities offering access to basic infrastructural elements (e.g., attics, basements) where HomeNet cables were situated, ISPs offering the necessary internet connection, and peer communities offering exchange of knowledge and expensive resources.

The BUI development process is driven by the interplay between members and technology, whereby members innovatively enact IT to address their unsatisfied or emergent needs and technology sometimes resists the users'

intentions (Pickering, 1995). In this way, this interplay contributes important emergent aspects that the innovators did not preview and/or cannot completely or directly control (Leonardi, 2011). For example, limitations of cable performativity led to BUI in networking technologies (e.g., cable boosters, uses of nontypical cables, unconventional use of TV antennas) in egalitarian HomeNets; slow peer-to-peer network protocols motivated server development and innovations in chats in meritocratic HomeNets; and the incompatibility of DIY and professional equipment motivated rewiring network architectures in core–periphery HomeNets.

Furthermore, BUI development and accommodation (Ciborra, 2004) by users proceeds in parallel with changes to the innovating community through the development of volunteer and self-organized roles and structures. As discussed in the findings section, different cycles of BUI development contributed to the development of diverse community structures (egalitarian, meritocratic, etc.).

Finally, the post-BUI development process is driven by the interplay between the BUI technology and the context. As our model illustrates, it unfolds after the needs of community members become satisfied and takes place beyond community boundaries since BUI technologies met needs unanticipated by its developers. As community BUI becomes knowable to diverse external actors, they reimagine the existing uses of the BUI to address their unsatisfied needs, often unexpected to the innovating members, which in turn leads to the involvement of more members and changes in the community boundaries. Our findings and the proposed model offer several theoretical and practical implications.

5.2 Theoretical Implications

Our findings and the proposed model contribute to our knowledge on processual and evolutionary aspects of BUI development, illuminate the role of context and technology in BUI development by the innovating members, and link community BUI development and community survival and success over time.

Processual understanding of BUI development. Along with highlighting innovative user–technology enactments, our findings highlight contextual conditions that motivate BUI emergence as well as developments that proceed after BUI satisfies user needs. In this regard, our study contributes to a processual understanding of BUI development where IT users, technologies, and contexts are continuously evolving and mutually shaping.

Previous studies on BUI have prevailingly focused on stable and bounded sets of users in organizations, for example university workers, automotive designers, hospital and library staff, and corporate employees

(Bagayogo et al., 2014; Leonardi, 2011; Morrison et al., 2000; Oborn et al., 2011). Where a broader set of users has been considered, it has been limited by organizational boundaries, for example pharmacy units and groups and hospital workers (Barrett et al., 2012; Sergeeva et al., 2017). Some studies have opened the discussion on the potential impacts and interactions of qualitatively different sets of open and fluid users, for example users of social media and websites (e.g., Martini et al., 2013; Young & Leonardi, 2011).

Our findings and the proposed model build on and extend the above findings by incorporating an evolving set of heterogenous actors who contribute to and impact BUI development. Notably, our findings highlight a profoundly evolving nature of both direct users (e.g., innovating community members) and external actors who become dynamically related to BUI as it evolves.

Interplay between innovating members, context, and technology. Our study challenges previous findings about the leading role of individual lead users and the supporting role of user communities as the innovation consumers and feedback providers (e.g., Foster & Heeks, 2013; Prahalad, 2012; Shah & Tripsas, 2007; von Hippel, 2005). While we acknowledge the importance of intrinsic and social motivations in driving innovation developed by community members, we illuminate community BUI as an evolving collective process that is coshaped by the interplay between members, technology, and context (actors beyond community boundaries). In particular, our findings suggest several contingencies into how the above interplay drives the development of community BUI (see Figure 7).

As Figure 7 illustrates, the interplay between the context and the community coshapes the driving needs of BUI development (which might be specific or multiple), as well as the links with the circle of the supporting external actors (who might be close or distant to the community). The interplay between members and technology within communities generates diverse degrees of control over innovative contributions, ranging from low to high. Finally, the interplay between technology and context might attract new members with similar or diverse backgrounds. The above interplays characterize different types of community BUI.

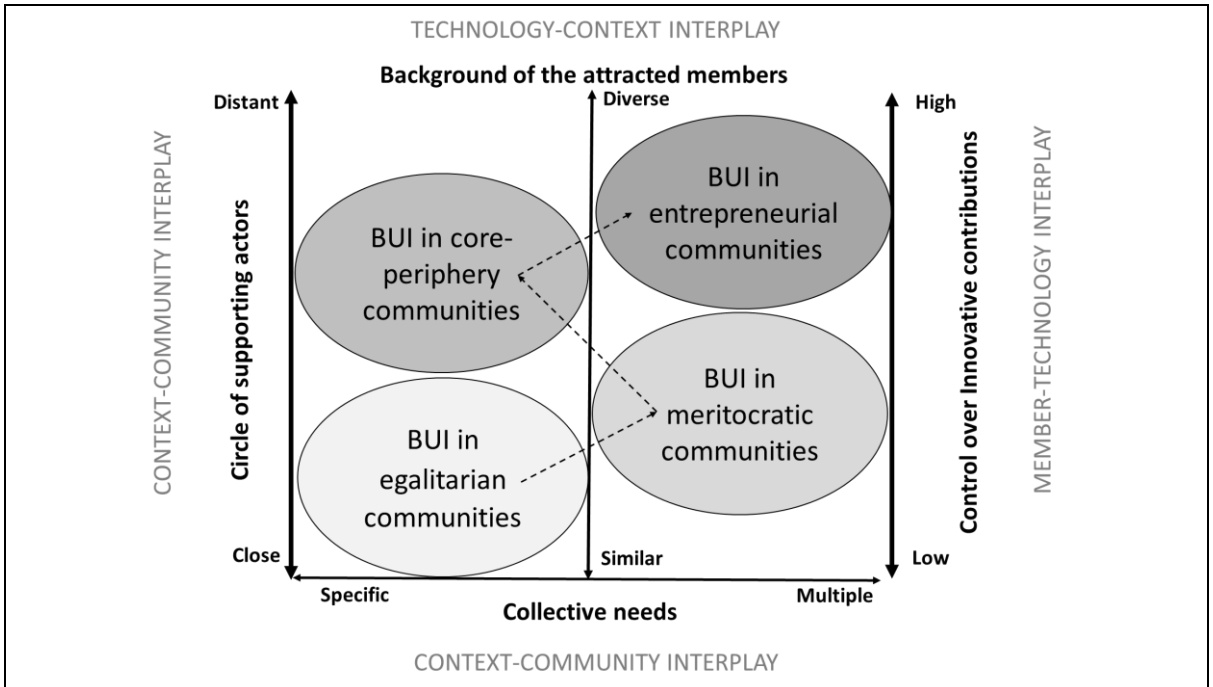

Figure 7. Interplay Between Members, Technology, and Context in Community BUI

Thus, *BUI in egalitarian communities* is characterized by specific needs (i.e., to play multiplayer games), close circles of in the contexts (i.e. supporting friends and relatives), similar (IT) backgrounds of the participating members, and low levels of control over innovative member contributions (i.e., reflected in interchangeable roles and flat community structures).

BUI in meritocratic communities is characterized by multiple driving needs (i.e., needs in online social activities, diverse services), relatively low levels of control over innovative member contributions (i.e., diversity of self-selected member roles and elected administrators), and wider context circle (i.e., friends and relatives, as well as municipalities providing access to attics and basements), as well as more diverse member backgrounds (compared to egalitarian communities).

BUI in core–periphery communities is characterized by specific driving needs (internet access), extended context circles (cooperation with internet service providers), diverse member backgrounds and increased controls over innovative member contributions (i.e., the core controlling contributions of other members).

Finally, *BUI in entrepreneurial communities* is driven by multiple driving needs (access to internet, access to general social activities provided by all ISPS, access to specific community services), relatively distant context circles (e.g., peer community ISPs, membership in the national ISP association). BUI entrepreneurial communities also relied on members with diverse backgrounds and high control over innovative member

contributions (i.e., developments that are motivated, curated and implemented by the entrepreneurial core members).

Our findings on the diverse types of community BUI importantly extend existing knowledge on the interplay between member(s) and technology, suggesting the channeling role of IT in community innovation (Halfaker, Kittur, & Riedl, 2011; Shaikh & Vaast, 2016). We argue that such dynamics are typical for communities with core–periphery structures, diverse member backgrounds, and a dominant need for specific IT services. In this regard, our findings on diverse types of community BUI illuminate multiple alternative paths of the member–technology interplay.

Furthermore, our findings on the important role of technology and context in BUI development suggest two theoretical implications. First, they illustrate technology and context contributions to emergent BUI development. Thus, innovative member developments and users' interpretive flexibility (Orlikowski, 2000) could not fully explain all BUI development since the interplay between the innovating members and materiality of technology often unfolded beyond the needs, intentions, and control of the members innovating with IT. Furthermore, our findings illustrate that technology triggers the development of new member roles and community structures. For example, the roles and statuses of those members who volunteered to engage in some tasks and responsibilities with community technology evolved with BUI developments (e.g., network operators, repairers, administrators).

The interplay between technology and context further escalated the emergent path of BUI development, contributing to its dramatic deviation from the driving needs, intentions, and control of the BUI innovators. As community technology developed, new acting (im)possibilities emerged (Ciborra, 2004) that become visible to heterogenous and unexpected external actors (Lyytinen & Yoo, 2002; Yoo et al., 2010), who reimagined the uses of the BUI to address their own unaddressed needs. Such contributions, in particular, contributed to shaping the agency of community users and how they became attuned to the world (Brigham & Introna, 2006; Ciborra, 2002, 2004; Kamoche & Cunha, 2001).

Second, our findings support and nuance the important role of context in community BUI development. Our study extends previous findings on the important role of actors beyond direct users in shaping user–technology enactments (e.g., Boudreau & Robey, 2005; Sergeeva et al., 2017; Vieira da Cunha, 2013; Young & Leonardi, 2011) by demonstrating the diverse various roles of such actors and their evolving nature (e.g., motivating collective needs, supporting actors). Furthermore, our findings illustrate that, while high IT-enabled boundary

permeability, e.g., widespread access of home computers, low cost of HomeNet equipment and internet, was important for boosting BUI development, it also forced the communities to continuously renegotiate their boundaries (Jarvenpaa & Lang, 2011) by accommodating new members and adapting to the continuously changing circle of external actors. Finally, our findings also specify possible contentious contributions of external actors (e.g., in our case, the state) on the desire and abilities of direct IT users to develop community BUI.

Community survival and success over time. Our findings enable us to go beyond the role of specific IT features, such as modularity and granularity, in explaining the successful development of user communities (e.g., Benkler, 2002; Benkler & Nissenbaum, 2006; Faraj et al., 2011; Raymond, 1999). In particular, we posit that the poorly understood ability of communities to attract and retain large number of members (e.g., Benkler et al., 2015) might depend on the process of post-BUI development and on the community's ability to accommodate users with new needs. Thus, the context where communities operate might be an important factor impacting not only community emergence (e.g., to address unsatisfied needs) but also community survival and growth. For example, communities that operate in the context of multiple heterogenous actors might increase the chances that their developed BUI will become knowable to other actors and reimagined for their needs (Yoo et al., 2010), possibly generating a new wave of community BUI development. Furthermore, communities with more permeable boundaries might be subject to more intensive BUI and technology reuse from heterogenous members and thus potentially more innovation and higher sustainability and longer-term survival. At the same time, our findings on the diverse HomeNet development paths, as a result of prohibitory state laws and attempts by ISPs to absorb HomeNets, suggest that communities' ability to remain resilient, adapt, and maintain their boundaries also contributes to their innovativeness. Indeed, only those HomeNets that dynamically adapted to the imposed restrictions by legitimizing as smaller communities and transforming into HomeNet ISPs, rather than attempting to keep their boundaries intact or allowing these to dissolve, continued BUI development and continued successful growth.

Furthermore, as our model illustrates, an important part of previously untheorized BUI dynamics takes place when IT users external to communities reimagine community BUI uses beyond those imagined and predefined by the community innovators. Based on these findings, we argue that the extent to which BUI permeates to incorporate the diverse needs of both current users and current outsiders are key factors shaping the success of communities over time. This might shed light on why only a limited number of communities succeed over time (Benkler et al., 2015).

5.3 Practical Implications

Our findings illustrate that organizations and practitioners collaborating with communities need to be aware of the profound coshaping impact of diverse external actors on BUI development and organizing and thus need to take a more proactive and responsible role. Second, partners of innovation communities need to develop dynamic and continuously updating communication strategies for engaging key members since a new wave of BUI might fundamentally rewire community roles and structures, as well as the community circle of important external actors. Third, community leaders need to be aware of the important coshaping role of context and interplays with external actors. As illustrated in our study, such interplays might significantly impact community innovations even when communities do not interact with these actors directly (e.g., egalitarian and meritocratic HomeNets); they might also boost community innovation and membership to an unprecedented scale (as in core–periphery HomeNets) or significantly limit and transform community BUI (as in entrepreneurial HomeNets). Fourth, a takeaway for practitioners collaborating with communities for innovation as well as community leaders is that settings with heterogenous actors may be more profitable for the development of community BUI since they increase the potential number of nonmembers who might reimagine BUI in different ways, as well as the number of potential supporting actors. Finally, our findings on the processes of BUI development (summarized in Figure 6) and contingencies on the interplays between innovating members, technology, and context (summarized in Figure 7) provide value for understanding how community innovation develops and what types of BUI are coshaped by the interplays. Such insights have important practical implications given numerous innovation initiatives by local communities helping local business, healthcare professionals or governmental agencies in addressing societal challenges (e.g. virtual hackathons and 3D printing initiatives to fight the challenges of Covid-19).

5.4 Future Research

Our findings highlight several important areas for future research. First, our findings suggest a need for future research to consider the agency of both innovating members and technology as active and mutually shaping. In particular, future research might build on this knowledge and develop further detailed insights into the agency of community technology and its performativity (e.g., Pickering, 1995; Leonardi, 2011). Second, our findings illustrate a need for scholars studying communities to further expand knowledge on external community-related actors who might not interact with community BUI directly yet influence its development via contextual inputs and post-BUI dynamics. That is, future research should investigate whether the interplay with external actors

might generate, or prohibit, certain trajectories or types of community innovation. Third, theory of BUI development in communities could profit from future research testing and further elaborating the contingencies identified in Figure 7. Finally, our findings illustrate a need for future research to expand their focus to incorporate not only community–technology interplay but also pre- and post-BUI development processes.

6 Conclusion

This paper is among the first to study how BUI longitudinally develops within communities. Our findings and the proposed model of BUI within community settings provide new insights into the emergent and continuously evolving processes of community BUI that is coshaped not solely by the innovating users but also by their interplay with technology and external actors and evolves beyond the needs and expectations of the original innovators. This study contributes to the undertheorized area of information systems on BUI within communities which generate alternative uses of IT beyond those originally imagined by organizations and individual user innovators.

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