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Knowledge Creation in Virtual Communities – Exploring Practices in Open Source Software Hacker Communities

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Abstract

This paper offers an exploratory conceptual and theoretical examination of knowledge creation within virtual communities of hackers. By distinguishing between different types of virtual communities, we argue that hacker communities involved in free and open source activities possess special structural and processual characteristics that are conducive to innovative product development. Drawing on diverse literatures, this paper thus builds an initial understanding of how a hacker community is organized and how knowledge creation and innovation occur in the hybrid virtual environment.

Keywords: Virtual Community, Hackers, Open Source Community, Community of Practice, Core-Periphery Structure.

1. Introduction

The growth of the Internet has led to the formation of new forms of social exchange, creating what are generically known as 'virtual communities' [1]. Virtual communities have received increasing attention in recent years. Numerous articles have emerged on virtual firms, organizations, and work teams, e.g., Jeppesen and Fredriksen[2], Faraj et al.[3] and Subramanian and Soh[4]. However there is little theoretical insight into the different ways that virtual communities can work. A hacker community provides one of the most intriguing examples of how virtual communities can be innovative on-line.

The diversity of communities, particularly in terms of their organization, control and development, makes generalization difficult, but this paper provides a typological framework for distinguishing virtual communities by their structural and processual attributes, and explores theoretical qualities of the phenomenon. The paper provides a window into several aspects of a hacker community, analyzing the theoretical implications for knowledge creation and innovation that characterizes one type of hacker communities: the open source software (OSS) community.

We argue that the OSS community has certain characteristics regarding membership, purpose and its core-periphery structure that makes it useful to explore the applicability of the theory of Communities of Practice (CoP) to this empirical domain. By examining peripheral participation and distributed problem-solving, for example, we can understand critical conduits for knowledge transfer and sharing within the community.

The aim of this paper is to explain the ways in which certain structural, processual and CoP characteristics support knowledge creation and innovation in hybrid hacker communities. Furthermore, the four knowledge conversion modes of the SECI framework (i.e. socialization, externalization, combination and

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internalization) are applied to a virtual hacker community to identify how knowledge creation and innovation can happen in such a community. The key research question is: How is knowledge creation and innovation sustained in virtual communities of hackers?

This paper begins by defining communities and virtual communities, goes on to discuss types of hacker and virtual communities, before considering how characteristics of innovative virtual communities can be understood through adopting the CoP concept. The paper concludes by evaluating the utility and relevance of conceptualizing knowledge-creating hacker communities as virtual communities of practice (VCoP) and outlining our future plans for empirically investigating this important phenomenon.

2. Virtual communities

In distinguishing between *Gemeinshaft* and *Gesellschaft* ('community' and 'association'), Tonnies provides the classical starting point for understanding the concept of 'community'. Gemeinschaft is tied together by a variety of shared interests, shared values and a feeling of camaraderie while Gesellschaft is created and sustained by the existence of contracts and rules among members [5]. This concept of community identifies six basic properties: dense social ties, institutional involvement, rituals, small size, shared perceptions of experience and a common belief system [6]. From his review, Brint [6, p. 8] proposes that communities refer to "aggregates of people who share common activities and/or beliefs and who are bound together principally by relations of affect, loyalty, common value and/or personal concern (i.e., interest in personalities and life events of one another)".

Brint's [6] emphasis on shared values and relationship based on personal involvement leads him to disregard work groups and voluntary interest organizations because they involve rational interests. However, he includes 'virtual communities', which are regarded as "communities in which members interact purely through the medium of computer technology" [6, p. 11]. Various elements have been attributed to virtual communities: e.g. people, shared purpose, socio-economic exchange, reliance on technology, culture, bonding and irregular interaction [7].

Another concept of a community, developed by Lave and Wenger [8], is the so-called Community of Practice (CoP). CoPs suggest that community boundaries are established through practice and person based networks, where members are interwoven in the fabric of knowledge [9]. Lave and Wenger [8, p. 98] described a CoP as "…a set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice". They draw on the notion of apprenticeship to explain processes of knowledge acquisition and learning, viewing it as a form of *socialization* into a community. The newcomer gradually becomes a legitimate member of the CoP through learning the community's accepted practices, its language and its conventions during processes of interaction with established members [10]. This approach highlights the importance of core-periphery relationships and legitimate peripheral participation in understanding knowledge-sharing processes within physical occupational settings.

'Virtual communities' have been conceptualised from sociological and technological perspectives and there has been some reference to their knowledge-creating or innovative characteristics. For instance, Hsu *et al*, (2007, p. 153) define virtual communities as "a cyberspace supported by information technology and centered upon communications and interactions of participants to build collective knowledge". Knowledge creation aspects of VCoPs in relation to the involvement of lead-users were identified by Mahr and Lievens [11]. Focusing on user led virtual innovation activities, Füller, Jawecki and Mühlbacher [12] identified in their research about online basketball communities that users can actively contribute to the development of high quality innovations by sharing and creating knowledge. In addition, Correia, Paulos and Mesquita [13] suggest a number of drivers and barriers for knowledge creation in VCoPs. These are hard and soft aspects, organizational aspects, trust, moral obligation, information and specialists being accessible, organizational culture and technological aspects.

Besides the above, other studies have examined knowledge creation in different types of communities. Using Nonaka's [14] knowledge creation spiral, ten conditions enabling knowledge conversion (i.e. tacit knowledge conversion) in a blog community were

identified. These conditions support the *ba* of socialization and externalization (*Ba* refers to the enabling context or place) [15]. In an applied study of virtual learning classes, Nonaka's [14] socialization, externalization, combination and internalization phases were supported by the originating, the dialoguing, the systematizing and the exercising *bas*, respectively [16]. Also using the Nonaka [14] knowledge creation framework, Hafeez and Alghatas [17] explained how knowledge creation happens through story telling and discourse analysis in a researcher, educator and practitioner VCoP.

In relation to the Linux kernel development project, which is a software development VCoP, knowledge creation happened through an evolutionary process of learning based-on criticism, as errors were identified, detected and rejected. In the Linux project, criticism was supported through norms and organizational structures. These characteristics eventually led to product innovations [18]. By examining electronic networks (which is another type of VCoP) through a social capital lens, Chou and Chang [19] identified factors that facilitate knowledge creating behaviour.

Based on research in an open source VCoP, Hemetsberger and Reinhardt [20] suggested that knowledge sharing and creation is facilitated through processes and technologies that implicitly enable reflection. Their suggestion is based on a combination of 'the reflective practitioner' concept [21] and the CoP literature [8]. Regarding knowledge creation through using technology and forming discursive practices, Hemetsberger and Reinhardt [22 p. 187] identified that virtual re-experience is enabled. This re-experience is also facilitated through "code, transactive group memory, instructive content and discourse, and reflective discourse". Finally, Sarma and Matheus [23] offer a process theory of knowledge integration and innovation in the context of hybrid open source software virtual communities of practice. Their process theory comprises various recursively intertwined structural and social features as well as three process theory ideal types, i.e. the teleological, the evolutionary and the dialectical, based on Van de Ven and Poole [24]. Through this, these authors explain the episodic progression of an innovation through different phases of an innovation process.

Based on the discussion above we can see various similarities between the earlier concept of *Gemeinschaft* and the more recent phenomenon of virtual community, including the importance of social interaction and common values. However, virtual communities differ from the traditional 'physical' concept in that they are more reliant on technology, are task/activity based, more dispersed physically and are formed not due to geographical proximity but through self-interest. They thus appear to be more loosely knit with fewer enforced norms.

So far, different types of virtual communities have been examined in relation to their knowledge sharing and knowledge creating characteristics. However, a better understanding of knowledge creation in a specific type of VCoP, the hacker VCoP, is needed. The rationale for this is that the hacker community can be distinguished from other virtual communities based on their ideology, as they are governed by a specific code of ethics called the 'hacker ethic'. The ideology promotes free access to information systems for the development of the society, a contempt for organisations/regulations against free access to software and the promotion of a meritocratic system of valuing accomplishments based on technical competency alone, thus incorporating a mix of political, moral and technological values in the culture of the community [25].

3. The hacker community

In the study of virtual communities there is little reference to knowledge generation and innovation. A few authors, such as Lazar, Tsao and Preece [26], have considered the semi-virtual nature of certain communities, which we refer to as 'hybrid virtual communities'. That is, although they largely operate in the virtual environment, these communities also create occasions for face-face interaction. For the purpose of this paper, we focus on those hacker communities that are hybrid in nature and argue that they have the organizational potential to be knowledge based and innovative.

Levy [27] provides one of the earliest definitions of hackers, describing 'to hack' as an activity or project that is undertaken not just as an objective task, but for pleasure and involvement. The core elements of the early 'hacker ethic' emerge from this point and include the creative use of technology, the inclination towards

reverse engineering and a curiosity to explore systems [28]. As the generations of hackers have evolved, they have diverged and have taken on different interpretations of what it is to be a hacker, i.e. hacker identity. [29*]

The term 'Hacker' is a contested term and cannot fit into a single homogeneous description [30]. Researchers such as Jordan and Taylor [31] have viewed hackers as a community characterized by technology, secrecy, fluid membership, male dominance, anonymity ad motivations. Other researchers have classified hackers based on deviant attributes and factors such as activities, knowledge and motivation. Various taxonomies proposed have viewed hackers as being sociopaths with the intent to commit crime and acts of computer vandalism [32].

Chandler [33] classifies hackers, based on their attributes as elite groups, neophytes, losers and lamers. He describes the elite groups as being highly motivated, skilled and knowledge seeking while the other groups as possessing varied levels of criminal intent (Note: "In communities of open source programmers, "hacker" is a very positive term that is applied to very talented and dedicated programmers" [34, p. 209]. That is to say, we do not intend to provide guidelines for unlawful behavior in this paper). Although this suggests the presence of some ethical subgroups there is little reference to the open source community. Thus, the factors used to arrive at such taxonomy cannot be applied to the community as a whole as the collective identity of the subgroups within the hacker community is shaped by various social norms, based on certain philosophical or ethical views.

Taylor [30] has suggested a classification that takes into consideration the heterogeneity of the hacker community and is based on the constellation of practices of the various subgroups.

Figure 1: A taxonomy of hackers
Source: Developed for this study based on Taylor [28]

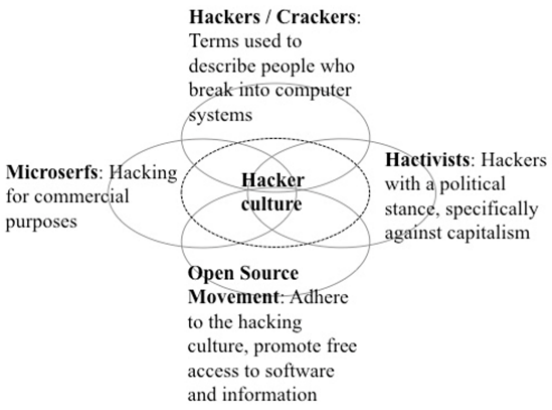


Figure 1 distinguishes four subtypes of hacker culture. Hackers/Crackers are terms used for people who break into computers, however the term 'hacker' is used by the community for member sharing to the ethical values and the term 'cracker' is used by computer security industry. Microserfs are groups that hack for commercial gain, they are ethical but focused on commercial success while Hactivists take a moral stance again certain issues but do not necessarily penetrate systems. Politics are the focal point of the groups.

The open source movement is shaped by the original hacker values. Raymond [35] dates the origin of the hacker culture to 1961, in the MIT computer laboratories, where the name 'hackers' was first used [29]. He emphasizes that the 'programmer culture', known later as the' hacker culture', gave rise to interactive computing and, more importantly, established a new

* Other definitions of hacker [29, p. 339-340] "[originally, someone who makes furniture with an axe] 1. A person who enjoys exploring the details of programmable systems and how to stretch their capabilities, as opposed to most users, who prefer to learn only the minimum necessary. 2. One who programs enthusiastically (even obsessively) or who enjoys programming
rather than just theorizing about programming. 3. A person capable of appreciating hack value. 4. A person who is good at programming quickly. 5. An expert at a particular program, or one who frequently does work using it or on it; as in `a Unix hacker'. (Definitions 1 through 5 are correlated, and people who fit them congregate.) 6. An expert or enthusiast of any kind. One might be an astronomy hacker, for example. 7. One who enjoys the intellectual challenge of creatively overcoming or circumventing limitations. 8. [deprecated] A malicious meddler who tries to discover sensitive information by poking around. Hence `password hacker', `network hacker'. The correct term for this sense is cracker."

tradition of software programmers who push the limits of the doable.

Much research on hackers thus far has viewed them as criminal deviants focusing on technical solutions to protecting systems [36]. A large number of studies have also been devoted to understanding the motivation behind hacking. For example, researchers such as Goldschmidt [37], Taylor [30] and Lakhani and Wolf [38] have attempted to profile hackers and have explored their motivations for participating in hacking practices. Some of the most common characteristics identified as drivers for participation are extrinsic factors such as career advancement, monetary benefits, job prospects and intrinsic factors such as curiosity, excitement, thrill, creativity and intellectual stimulation.

Although these diverse accounts are insightful and provide valuable information about the hacker culture, they leave many questions unanswered. For example, they do not take into consideration the underlying social and cultural mechanisms associated with the 'gift culture', which has been associated with hacker communities that give away software codes, ideas and prototypes [39]. In a gift economy, social relations are not regulated by monetary transactions, but maintained by a set of rules governing production, exchange, distribution, competitiveness and status [40]. However, we need to develop a more complex set of theoretical ideas in order to explain the practices within hacker communities that lead to knowledge generation and software development.

4. Hybrid knowledge-creating communities and virtual communities

4.1. *Typologies of virtual communities*

Several different classification schemes address variations in virtual community. For example, Hagel III and Armstrong [41] have classified communities as either business-to-business or consumer-focused, while Markus [42] distinguished between virtual communities based on their social, professional and commercial orientations. Kozinets [43] identifies two main dimensions of primary group focus and social structure. Social structure can vary between low and high, while group focus can be based on information exchange or social interaction.

These typologies provide valuable insights into virtual communities, but other factors seem to be more important – and in need of further development – if we are to explain their knowledge-creating potential. Based on existing research, Table 1 distinguishes between four sub-types of organized activity within virtual environments according to structural, processual and outcome factors. This allows us to clarify further the specific characteristics associated with knowledge and innovation practices.

Traditional virtual organizations are geographically distributed commercial companies, in which members assume well-defined roles and relationships that may be independent of the role in the organization employing them [44]. Problem solving communities and voluntary social groups deal with particular types of social and technological issues. Hybrid knowledge creating communities are characterized by innovation, transparency and efficient use of knowledge [45].

Each of the four types of virtual community can be conceptualized according to eight general dimensions, which are adapted from the work of Lazar and Preece [46], Lazar, Tsao and Preece [26], Ahuja and Carley [44], Gläser [47] and von Krogh, Spaeth and Lakhani [45]. The first three are essentially structural. Virtual communities vary in the basis of membership (e.g. degrees of voluntariness), the form of control used (e.g. formality) and the kinds of boundaries that define them (tight to permeable). The next four are related to internal processes. These communities vary in the ways in which members identify with the group (e.g. through occupational membership or common task), how they relate to a physical community (based in face to face interactions or purely virtual), institutionalization of practices (how practices are legitimized) and knowledge sharing and exchange (how different kinds of knowledge are spread among members). The final factor identifies the outcomes of the different forms of organizing.

In the context of an exploratory paper, this systematic comparison helps to clarify the distinctive structural and processual characteristics of hybrid knowledge-creating communities in relation to other types of virtual community.

Table 1: Sub-Types of Virtual Communities
Source: Developed for this study based on Lazar and Preece [46], Lazar, Tsao and Preece [26], Ahuja and Carley [44], Gläser [47] and von Krogh, Spaeth and Lakhani [45]

	Traditional virtual Organization	**Problem solving community**	**Voluntary social groups**	**Hybrid knowledge creating communities**
Examples	Commercial organizations	Technical groups such as 'yahoo answers'	Social support groups such as 'I-Village'	Free and open source software community
Basis of Membership	Based on location and profession	Participation in creation of artefacts	Based on common interest	Based on values, goals and legitimate peripheral participation
Degree of Boundedness	Tightly bound	Semi fluid boundaries	Fluid boundaries	Loosely knit at the boundaries but with a core at the centre
Focus of group interaction	Common occupation	Creation of artefacts	Shared interest	Shared goal, ideology and ownership
Relationship with a physical community	Based on physical communities	Not related to physical communities	Somewhat related to physical communities	Somewhat related to physical communities
Institutionalization of practices	Practices based on rules and procedures	Based on knowledge sharing	Based on need for collective action	Based on creation of intellectual property
Knowledge sharing and exchange	Low exchange with generation of explicit knowledge	Creation of artefacts based on tacit and explicit knowledge	High knowledge exchange for social purposes	Highly innovative with creation of social and technical artefacts based on tacit knowledge
Main Outcomes	Development of commercial products	Providing solutions	Social Support	Knowledge creation and dissemination

4.2. *Social Learning and Community*

Another way of examining this knowledge creation potential of hacker communities is provided by the communities of practice (CoP) framework, which was developed as a theory of social learning [8]. Underlying this approach is the concept of 'situated learning', in which, in collocated work groups, knowledge is transferred from experienced workers to apprentices through social interaction and the embodiment of certain beliefs and behaviour. This suggests that learning is bound to the context in which it is shared and to the kind of knowledge being transferred. In the same vein, Brown and Duguid [48] focus on formal and informal organizing where members develop a shared identity that facilitates the transfer and sharing of knowledge.

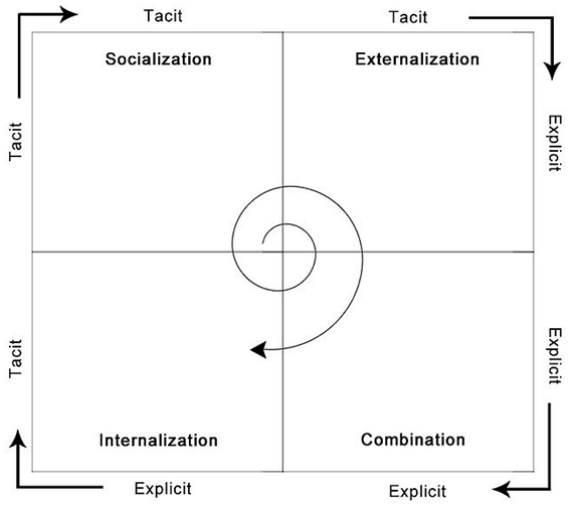
In summary, we have discussed that hacker communities involved in OSS-work share some characteristics of CoPs and may therefore benefit from being examined within this framework. OSS communities are innovative, are geographically dispersed, and operate in virtual settings and have strong beliefs that software products should be free for use and distribution [49].

5. The Hacker Community, Knowledge Creation and the Virtual CoP

5.1. *Knowledge creation in a hacker community*

In relation to virtual hacker communities, knowledge creation can happen in a similar vein as discussed above by, for example Sinclair, Martin-Niemi and Greatbanks [15] and Hosseini [16], in different types of virtual environments. Due to the hybrid nature of virtual hacker communities different kinds of "ba" exists separately or in combination. The originating 'ba', i.e. the place where hackers develop empathy, shared feelings, experiences and mental models, can be associated with the physical nature of hybrid virtual hacker communities. This is important for socialization and is dependent on face-to-face interaction. For example, hackers engage in an informal exchange to solve a joint software problem. In Nonaka's [14] SECI model, this is the starting point for knowledge creation (see Figure below).

Figure 2: The SECI model



Source: based on Nonaka [14]

The interacting 'ba' is a more consciously created place where hackers jointly engage in conversations, question ideas of their peers and think about their own ideas in relation to ideas of others. This is important for externalization. In a hacker community context, an example is setting up a task force and a plan to solve a software-related or programming-related problem.

The cyber 'ba' is the virtual place where hackers can combine new knowledge with existing information and make it available throughout the virtual community. This is facilitated though information communication technology (ICT) and is vital for combination. For instance, hackers can share programming codes in an OSS programming environment and use the shared information to advance the software.

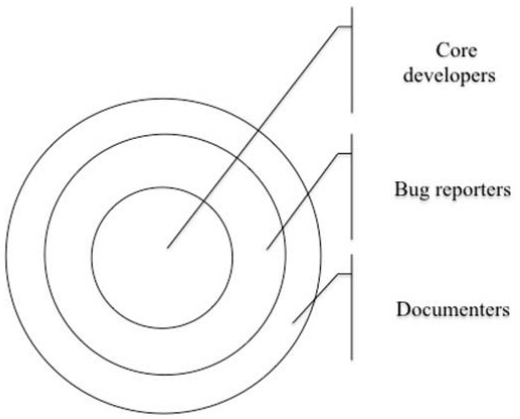
The final place through which knowledge creation is supported is the exercising 'ba'. Here formal explicit knowledge can be applied through work-based training and active involvement. This process is important for internalization. Hacker community examples are the notions of apprenticeship and legitimate peripheral participation.

5.2. *The structure of a virtual hacker community*

In Figure 3, we apply the structural ideas of core-periphery relations to examine the knowledge-creating work of open source hacker communities. Based on the existing literature, it is proposed that the open source community has an onion-like structure with key contributors at the 'core' of the project and members at different levels, based on expertise and involvement in the innovation project [50].

Figure 3: Core-periphery relations in the virtual CoP

Source: Ye and Kishida [51]



Empirical studies have found that, in a large majority of Open Source projects, a core group is responsible for a great proportion of the work accomplished and a very large group of peripheral participants is responsible for the remainder [52-54]. This raises questions about the value of peripheral members in the community about why they are involved in the community despite their meager contributions, while the core developers could easily create a private group and disregard non-contributors. The concepts of legitimate peripheral participation, strong/weak ties and knowledge stickiness shed some light on this puzzle.

Borgatti and Everett [55] distinguish between the core and periphery based on the density of ties among the participants. They conceptualize the periphery as comprising members associated with the core and wanting to move into the core. Core members are also characterized as being closely knit while peripheral members are more loosely knit with more ties to the core than with each other. Lave and Wenger [8] distinguish between the core and periphery by specifying that members at the periphery have limited knowledge and cultivate the skills through the process of apprenticeship, i.e. by undertaking a journey from periphery to centre, through the process of legitimate peripheral participation (LPP). LPP suggests that peripheral members understand the practices of the community and develop skills by legitimate participation in community practices, over a period of time [8].

We argue that hybrid knowledge-creating communities such as OSS share many of the characteristics of CoP. Open source communities, as seen earlier, are a hybrid between physical and virtual communities. They are characterized by three dimensions: membership, i.e. people experience feelings of belonging to their virtual community; influence i.e. people influence other members of their community; and immersion, i.e. people feel the state of flow during virtual community navigation. These dimensions reflect respectively the affective, cognitive, and behavioural aspects of virtual community members [56].

5.3. *Strong and weak ties in virtual hacker communities*

There are limits to the relevance of the CoP concept. Lave and Wenger [8] do not acknowledge the presence of a central core and further do not consider LPP as a knowledge-generating process, but rather examine it through a social learning lens. Unlike a CoP, in which the periphery comprises members who develop skills to attain full membership to the community, the core and peripheral members are involved in creating innovative artifacts and practices and thus need to be viewed differently.

Granovetter [57] suggests that weak ties are greater facilitators of information than strong ties and will traverse greater social distances, operating as bridges between different sub networks. Therefore peripheral members do not necessarily have limited knowledge but possess diverse knowledge and serve as a resource for

knowledge diffusion. Further seminal work on the stickiness of knowledge [58] implies that the locus of innovation shifts to where the information is sticky, leading to task subdivision in order to draw upon multiple sources of sticky information. If this is so, in OSS projects innovation will primarily occur at the periphery, which will contribute unique knowledge to the core. These theoretical insights indicate that in the OSS community peripheral members bring in newer knowledge, acting as knowledge brokers. Further as members have weaker ties at the periphery, novel information is transferred to the core.

5.4. *Evolving participation in virtual hacker communities*

We can extend the CoP theory to the virtual community. We theorize that knowledge sharing, knowledge creation and innovation occur over a period of time as a developing process of increased participation.

We suggest that members initially join the hacker community as free riders, seeking information but over a period of time begin to gradually participate and share information with other members. This leads to members developing a virtual identity and building ties with other participants. As this progresses, trust is established and participants who were once only interested in seeking information become established members and start contributing to knowledge creation and dissemination within the group, thereby creating technological artifacts, through social mechanisms. This evolving participation and the subsequent outputs of knowledge creation and innovation are facilitated through the four knowledge conversion modes explained above.

Thus the open interaction architecture of the open source community causes a shift in the dynamics of organizing within the community. The differentiation between the explanation offered here and the process theory offered by Sarma and Matheus [23] is that the focus in the current paper is on knowledge creation by integrating Nonaka's [14] SECI framework with particular aspects of the CoP notion (i.e. LPP / social learning / apprenticeship) [8] and by applying these ideas to a virtual hacker community.

6. Conclusion

This paper contributes to the virtual community literature by focussing on a particular type of virtual community, the hybrid hacker community. In doing so, the four knowledge conversion modes of the SECI framework were applied to a virtual hacker community in conjunction with the concept of '*ba*'. As the SECI model does not consider the mediating role of technology and the relationship between various elements of a virtual hacker community, the paper offers an explanation regarding the ways in which certain structural, processual and CoP characteristics support knowledge creation and innovation in this specific community.

A limitation of this paper is that we examined a virtual hacker community from a possession perspective of knowledge (for details see [59]) and neglected practice perspectives of knowledge. The above points towards three directions for future research.

First, the different characteristics explained above could be empirically examined through interviews or ethnography in an actual virtual hacker community. This way the hacker community characteristics could be examined from a success and failure perspective in relation to knowledge creation and innovation. Second, a questionnaire could be applied to statistically test associations between the hacker community characteristics and their subsequent impact on knowledge creation and innovation. Third, hacker communities could be researched from a practice perspective of knowledge through a longitudinal field study.

An implication for practice for hacker communities is that members in the periphery seem to play an important role in relation to the creation of new knowledge. Furthermore, it is important to highlight that a myriad of social mechanisms are at play in a virtual hacker community. Hence, our explanation provides an initial heuristic for a hacker community. However, to obtain a holistic view regarding structural, processual, CoP and knowledge creating characteristics of a virtual hacker community, contextual specificities have to be taken into consideration.

We have already used some of these foundations for our own empirical research and conducted a pilot study in the United Kingdom and India with members of hybrid hacker communities. With an attempt to build theory in this area of research, we have adopted an inductive approach that, within the broad outlines of the framework above, seeks to construct a detailed and deep understanding of the phenomenon from the ground up [60]. Such a qualitative approach also suits the processual orientation of the research project [61], through which we aim to examine the knowledge creation processes over time within hybrid hacker communities.

The research project is designed to examine these processes from the perspective of the hackers themselves. We have, to date, conducted 15 interviews with developers of the Gnome project, in the UK, followed by 9 interviews in India. Each interview was based on a semi-structured questionnaire, designed to develop first-order accounts of social process within hybrid hacker communities. The preliminary findings seem to suggest the existence of different types of '*ba*' during the four phases of Nonaka's [14] SECI framework. In addition, some of the structural, processual and CoP features explained above seems to emerge as being relevant for hybrid hacker communities to enable knowledge creation and innovation. For example, evidence points towards the presence of stronger social ties at the core and weaker social ties in the periphery of hybrid hacker communities, which also highlight the importance of the weaker social ties regarding knowledge creation and innovation.

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