Knowledge Creation and Innovation in the Virtual Community – Exploring Open Source Practices

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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 community, we argue that certain structural and processual characteristics are more likely to be associated with knowledge creation and innovation in virtual communities that are both 'hybrid' and knowledge-creating. Such a subtype is innovative and geographically dispersed, while being constituted by both physical and virtual forms of interaction. Hacker communities involved in free and open source activities possess special structural and processual characteristics that are conducive to innovative product development. We suggest that this form of knowledge-generating, knowledge sharing virtual community may benefit from being seen within the framework of communities of practices, and, despite certain shortcomings, sketch out the contours of the hybrid knowledge-creating community as a 'virtual community of practice'. Drawing on diverse literatures, this paper thus builds an initial understanding of how the hacker community is organized and how knowledge sharing and innovation occurs in the hybrid virtual environment.

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

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' (Klang & Olsson, 1999). Virtual communities have received increasing attention in recent years. Numerous articles have emerged on virtual firms, organizations, and work teams. However there is little theoretical insight into the different ways that virtual communities can work. The 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 allows us to explore theoretical qualities of the phenomenon. The paper provides a window into several aspects of the hacker community, analysing the theoretical implications for knowledge creation and innovation that characterizes one type of hacker community: 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.

This paper begins by defining communities and virtual communities, goes on to discuss types of hacker and virtual community, before considering how characteristics of the innovative virtual community can be understood through adapting 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 empirical investigating this important phenomenon.

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 (De Cindio *et al.*, 2003). 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 (Brint, 2001). From his review, Brint (2001) proposes that communities refer to '[A]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 (2001) 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 technology' (Brint, 2001).

Although other authors have conceptualised 'virtual communities' from sociological and technological perspectives, there has been little reference to their knowledge-creating or innovative characteristics. As an exception, Hsu *et al*, (2007) define virtual

communities as ‘a cyberspace supported by information technology and centered upon communications and interactions of participants to build collective knowledge’. Various elements have been attributed to virtual communities: e.g. people, shared purpose, socio-economic exchange, reliance on technology, culture, bonding and irregular interaction (Gupta and Kim, 2004).

Thus, 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.

The Hacker Community

In the study of virtual communities there is little reference to knowledge generation and innovation. A few authors, such as Lazar *et al.* (1999), 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 (1984) 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 (Taylor, 2005). 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.

The term ‘Hacker’ is a contested term and cannot fit into a single homogeneous description. (Taylor, 1999). Researcher such as Jordan and Taylor (1998) 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. (Rogers, 2000).

Chandler (1996) classified 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. 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 (1999) 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.

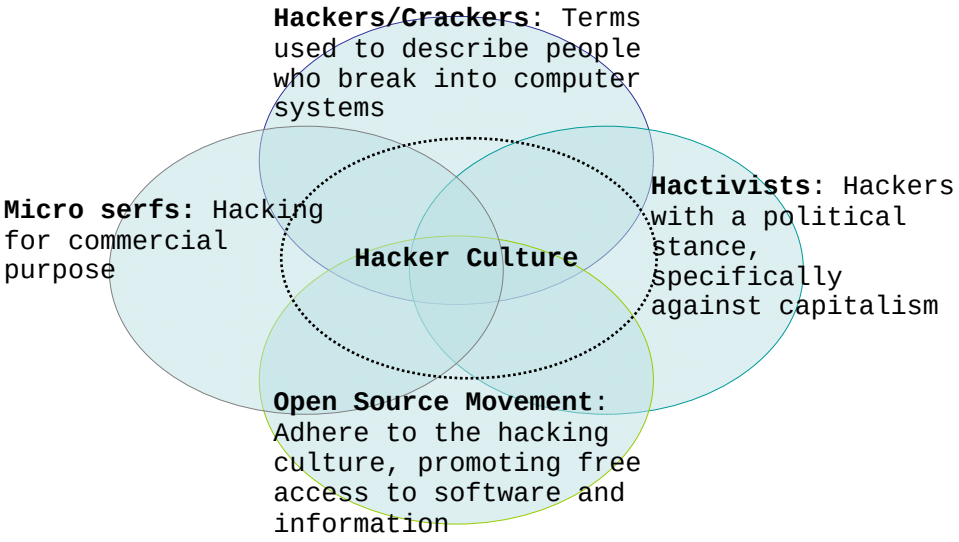

Figure 1: A taxonomy of Hackers (Adapted from Taylor, 2005)

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.

We suggest that these sub- groups share a common ground; they are characterized by the use of unconventional mechanisms of coordination, ad-hoc interactions, and geographical isolation and governed by their self interests. . However the open source community deviates from the other subgroups in that although they possess the same functional attributes their philosophy and culture is different form the other sub groups. Open source developers channelize their interest in the creation of software artefacts and have evolved a complex process that is not only reliable and flexible but also ensures the quality of the end product. They are governed by an unwritten set of rules, at the heart of which is the ‘hacker ethics’, i.e. to promote free software. (Mackenzie, 2002)Our empirical focus is on hackers involved in the innovative work of the open source software movement.

The open source movement is shaped by the original hacker values. Raymond (2001) dates the origin of the hacker culture to 1961, in the MIT computer laboratories, where the name 'hackers' was first used. He emphasizes that the 'programmer culture', known later as the' hacker culture', gave rise to interactive computing and, more importantly, established a new 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 (Hollinger, 1991; Sukhai, 2004; Smith, 2002). A large number of studies have also been devoted to understanding the motivation behind hacking. For example, researchers such as Goldschmidt (2005), Taylor (1999), Lakhani and Wolf (2005) 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 (Bergquist and Ljungberg, 2001). 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 (Lin, 2003). 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.

Hybrid knowledge-creating communities and virtual communities

Several different classification schemes address variations in virtual community. For example, Hagel and Armstrong (1997) have classified communities as either business-to-business or consumer-focused, while Markus (2002) distinguished between virtual communities based on their social, professional and commercial orientations. Kozinets (2000) 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 (Ahuja and Carley, 1999). 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 (Von Krogh et al., 2003).

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 (1998) and Glaser (2001). 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.

Table 1: Sub-Types of Virtual Communities

	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 artifacts	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 artifacts	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 artifacts based on tacit and explicit knowledge	High knowledge exchange for social purposes	Highly innovative with creation of social and technical artifacts based on tacit knowledge
Main Outcomes	Development of commercial products	Providing solutions	Social Support	Knowledge creation and dissemination

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. Characteristics such as membership, form of control and boundedness influence the likely extent of participation, the perception of shared interests and the extent of formalization and hierarchy within the community. We argue that the structural characteristics of hybrid knowledge-creating communities are more likely to be associated with processes – such as group identification, relationship with the physical community and institutionalization of practices – that affect the capacity of the community to share and create

knowledge and thereby create innovative social and technological artifacts as community outcomes.

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 (Lave & Wenger, 1991). 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 (1991) focus on formal and informal organizing where members develop a shared identity that facilitates the transfer and sharing of knowledge.

The notion of CoP suggests that community boundaries are established through practice and person based networks, where members are interwoven in the fabric of knowledge (Pan & Leidner, 2002). Lave and Wenger (1991) 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 (Hildreth & Kimble, 2002). This approach highlights the importance of core-periphery relationships and legitimate peripheral participation in understanding knowledge-sharing processes within physical occupational settings

We argue that hacker communities involved in OSS work share some characteristics of CoPs and may therefore benefit from being examined within this framework. OSS communities focus on creating innovative technological products, are loosely bound, and operate in virtual settings and have strongly held beliefs around the idea that software products should be free for use and re-use (Lakhani & Von Hippel, 2003). The voluntary nature of participation in the development of free goods raises important questions about the structure of the community and how it generates knowledge.

The Hacker Community, Knowledge Creation and the Virtual CoP

In Figure 2, we apply the structural ideas of core-periphery relations to examine the knowledge-creating work of open source hacker communities. Based on numerous case studies, 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 (Crowston & Howison, 2003)

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 (Ghosh & Prakash, 2000; Healy & Schussman, 2002; Mockus, A *et al.*, 2000). 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.

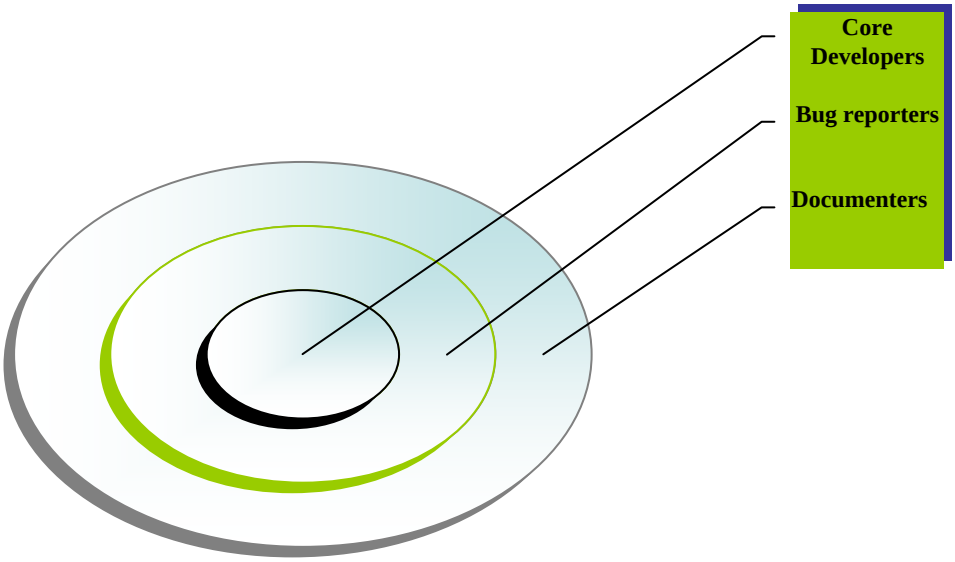

Figure 2: Core-periphery relations in the virtual CoP (after Ye *et al.*, 2002)

Borgatti and Everett (1999) 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 (1991) 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 (Lave & Wenger, 1991).

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 (Koh & Kim, 2004).

However there are limits to the relevance of the CoP concept. Lave and Wenger (1991) 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 (1983) 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 (Von Hippel, 2002) 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.

Figure 3 illustrates this extension of CoP theory to the virtual community. It shows knowledge-sharing as part of the process of hybrid knowledge-creating communities, with innovation occurring over a period of time as an evolving process of increased participation.

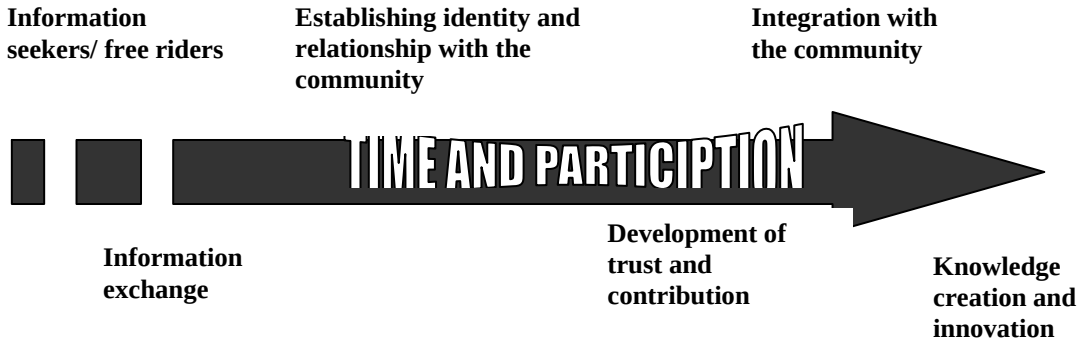

Figure 3: Process of Innovation in Hybrid knowledge Creating Communities.

Initially information seekers join the community for personal gain, but gradually begin to share information with other participants; this leads to establishing an identity within the

community and building a relationship with other members. Over time, trust develops and the participant who was once a free information-seeker becomes an established member of the community and is integrated within the team, thus contributing to creating and disseminating knowledge and, in the process, developing social and technological artifacts.

Thus the open interaction architecture of the open source community causes a shift in the dynamics of organizing within the community. Further research, using CoP to deconstruct the social structure would provide valuable information on how core and peripheral members play important roles in the development of software by providing unique streams of knowledge that facilitates the collective knowledge generation.

Summary

This paper presents an initial exploration of how certain hybrid hacker communities are organized in ways that promote knowledge sharing and innovation. We argue that such hybrid knowledge-creating communities are systematically different from other virtual patterns of behaviour along a number of conceptual dimensions. The identification of these factors enables us to construct an initial and tentative set of theoretical ideas through which to investigate the processes of knowledge sharing, knowledge creation and innovation in OSS communities. The theory of communities of practice provides other conceptual and theoretical pointers to important internal processes and hints at directions for future research.

Our empirical research follows from these foundations. Already, we have conducted pilot research in the United Kingdom and India with members of the OSS communities. Given the sparseness of theoretical knowledge in this field, 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 (Meyers, 1997). Such a qualitative approach also suits the processual orientation of the research project (Orlikowski, 1993), through which we aim to examine the knowledge creation processes over time within OSS communities.

The research project is designed to examine these processes from the perspective of the hackers themselves and we have to date – but as pilot to explore the appropriateness of the above framework – 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 are yet to be fully analysed, but they are sufficiently promising to encourage us in the current research direction.

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