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Free Space Optics in the Czech Wireless Community: Shedding Some Light on the Role of Normativity for User-Initiated Innovations

Johan Söderberg[1]

Abstract

The article investigates how users in the Czech wireless network community invented a technology for sending data over visible, red light. For five years, this was the most affordable method for connecting computers. The development of this technology was guided by the idea that it should be controlled by its users. With reference to this experiment, it is argued that a shared ethical and/or political vision can contribute to the establishment of norms within user communities encouraging their members to share information with each other. Thus, it is suggested that ethical and political convictions can be crucial for enabling collective innovation processes. This highlighting of normativity is intended as a complement to the common premise in Innovation Studies that users innovate to satisfy unfulfilled needs. In

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opposition to this view, it is argued that the needs of users are not a constant but something which emerge together with the transformation of the user community and the technology in question. Particular focus is placed on the tension between, on one hand, the norms and ethical–political motives of the user community, and, on the other hand, the needs satisfied through product development, both stemming from the same innovation process.

Keywords
markets/economies, expertise, politics, power, governance, justice, inequality, protest, other

Introduction

"Ronja" stands for Reasonable Optical Near Joint Access. It is a piece of hardware used for sending data by means of visible light. The technology was developed in the Czech wireless network community. The philosophy behind the project states that anyone lacking previous knowledge of electronics should be able to build the device. To realize this vision, the mechanics and electronics have been designed on the basis of generally available, off-the-shelf components and the instructions for building the device are published on the Internet. These principles have been labeled "user-controlled technology." The idea of user control makes the Ronja project highly interesting to look at in the context of ongoing debates about user-initiated innovation. The concept has attracted much interest both in Innovation Studies (IS; Urban and Hippel 1988; von Hippel 1988, 2005; von Hippel and von Krogh 2003; Franke and Shah 2003; Lüthje, Herstatt, and Hippel 2005; Shah 2006) and in Science and Technology Studies (STS; Oudshoorn and Pinch 2003; Eglash, Croissant, and Chiro 2004; Rohracher 2005).

In a recent case study of a wireless community network in Leiden, Netherlands, Ellen van Oost, Stefan Verhaegh, and Nelly Oudshoorn connected the discussions in IS with those in STS. The three authors argued that the focus among IS researchers on the products created by users has not been matched by an equal interest in how the same innovation process gives rise to a user community (Oost, Verhaegh, and Oudshoorn 2009). I will pick up this thread by examining in more detail the often troubled marriage between a marketable product and a user community. The reservations in parts of the Ronja community concerning attempts to commercialize the technology speak of commitments behind the development project other than just the desire to satisfy consumer needs. A mixture of political ideas and artistic ambitions can be detected in these testimonies. Here, I will focus on the normative element and argue that it can be linked to the norm of sharing information. Both came under pressure from the ambitions to redesign the device into a commercial product. The principle of user control was abandoned and developers became less willing to reveal their ideas to each other. Starting with the experiences in the Ronja community, I will argue that the focus on entrepreneurship in much IS research, though it might adequately describe many mature user communities, tells us little about how user-initiated innovations come into being in the first place. My proposal is that political commitments are often crucial in creating a milieu of sharing and collaboration. Thus, the discussion leads us to the crossroad between STS and social movement theory as a fertile ground for investigating collective innovation processes (Hess 2005; Hess et al. 2008).

The article starts out by presenting the literature on user-initiated innovation. My reservations concerning IS perspectives are here developed in greater detail. My claims are then tested against the Ronja case. The empirical material stems from twenty-one interviews with people who have used, built, and contributed to the development of Ronja. Most of the interviews were carried out during a five months field study in the Czech Republic. A secondary source of information was individual Web sites related to the Ronja project, the Ronja mailing list (http://lists.pointless.net/pipermail/ronja/), and the discussion forum of the Czech wireless community (www.czfree.net). All interviews were held in English, but the majority of the written documents consulted are in Czech or Slovak. In the following section, the philosophy of user-controlled technology is described and how it was enacted by the Ronja community. Thereafter, it will be shown how these ideas collided with the different attempts to commercialize the technology. The conflicts that arose over commercialization, and the subsequent disintegration of the Ronja community are linked to a failure to reach a consensus over the political urgency of having a user-controlled hardware technology, which in turn might have forced users to share information about their design improvements. The main lines of argument are summarized in the concluding section.

A Theoretical Overview of User-Initiated Innovations, Normativity, and Entrepreneurship

Research into user-initiated innovation has turned the table on the traditional model of technological innovation and diffusion, where it is believed that innovations are initiated by firms and then trickle down to users through consumer markets. IS scholars have shown that companies often appropriate discoveries first made by users, or, alternatively, firms are started up by user-innovators becoming entrepreneurs. Examples range from sports equipment such as mountain bikes (Lüthje, Herstatt, and von Hippel 2005) to juvenile products (Shah and Tripsas 2007) to medical instruments (Lettl, Herstatt, and Gemuenden 2006). Furthermore, IS researchers have challenged the belief that innovation processes are always driven by economic incentives. Empirical studies have shown that discoveries often occur accidentally rather than through calculated and determined efforts. Even when user-inventors decide to start enterprises based on their discoveries, they might have other motives than profit making (Morton and Podolny 2002; Shah and Tripsas 2007). In these respects, IS researchers have contributed to a more nuanced picture of innovation processes.

However, Ellen van Oost, Stefan Verhaegh, and Nelly Oudshoorn, speaking from an STS point of view, criticize the IS literature for an impoverished understanding of the community as merely a place where ideas are exchanged. This fails to capture the richer life cycle dynamics of user communities. Drawing on a study of a wireless community network in Leiden, the Netherlands, they have proposed a conceptualization of user-initiated innovations whereby the community itself is an essential component in innovation (Oost, Verhaegh, and Oudshoorn 2009, 7). The inadequacy of the notion of community in IS has also been subject to some self-criticism. Part of the problem, according to Joel West and Karim Lakhani, is that the concept has been used so loosely that the so-called community is many times little more than an appendage of a firm. Their call for more stringency regarding the concept leads them to the conclusion that more attention needs to be given to the discrepancy between communities and firms (West and Lakhani 2008). Support for their observation can be found in the many disagreements that have accompanied the commercialization of the Ronja project. Based on these testimonies, the current study looks at the friction between the marketable product and the community, both produced through the same innovation process.

That commercialization of user-initiated innovations can have some unwanted side effects is well known to IS researchers. One such effect is that users will be asked to pay for goods and services, which they previously got for free (Shah and Tripsas 2007). The main problem identified in the literature is that members become reluctant to share information when they start to think of their ideas as business opportunities (Franke and Shah 2003; von Hippel and von Krogh 2006; Hienerth 2006). Consequently, “too much competition" can make the community model of organizing innovations unsustainable (Baldwin, Hienerth, and Hippel 2006, 1307). Although this risk is widely recognized, the overbearing question has been how firms can tap into user communities without endangering the willingness of users to disclose their information. Furthermore, voluntary disclosure is typically discussed from a game-theoretical point of view where the focus is on the benefits and costs to the individual (Harhoff, Henkel, and Hippel 2003). Siobhán O'Mahony's study of the free software community is a welcome exception in that she takes the community, and not the firm or the individual, as the starting point for her reflections. Rather than discussing voluntary disclosure in terms of opportunity costs, she asks how the obligation to share source code is upheld by the free software community. Free software projects must often defend themselves against attempts by firms to appropriate the source code and lock it up behind proprietary licenses. Several strategies have been developed by hackers to sanction transgressions and to protect the information commons. The invention of alternative licensing schemes such as the General Public License (GPL) is perhaps the most eye-catching example. However, O'Mahony finds in her study that the most important factor for upholding the custom of sharing information is the norms of the free software community (O'Mahony 2003).

Building on Siobhán O'Mahony's work, I propose that the norm among hackers to share information is intimately linked with a larger, political analysis. The imperative to share code is underlined by an anticipation of the negative implications for society, if users are denied full access to their software (Stallman 2002; Coleman 2004). This demonstrates one way in which political ideas can be said to foster collective innovation processes. Another reason for thinking that normativity can play a role for user-initiated innovation is suggested by the wireless Leiden project. The outward-looking, ideological ambitions of its instigators provided an incentive to share their inventions. Such an incentive would not have existed, if the people involved had just wanted to satisfy their own needs (Oost, Verhaegh, and Oudshoorn 2009, 13). Hence, when I foreground the importance of normative standpoints in user communities, I do so to problematize a central premise in IS research. Namely, the assumption that users innovate to satisfy their own, unfulfilled needs. Without doubt, the desire to get fast and cheap access to the Internet was the main reason behind participation in the Ronja project and in the Czech wireless scene. However, the stories coming out of this setting point toward numerous other motives for becoming engaged, some of which are connected to political ideas. It is true that the political relevance of the Ronja project hinged on a mass of users satisfying their needs through the technology. Even so, the alliance between the politically charged ideas and the technical function of the product was not straightforward. As much is suggested by the following complaint uttered by the main developer of Ronja:

> I sometimes get the feeling that people are not really interested in the political part, they are interested just in the fact that it is cheap, and it runs and it fulfils their needs. (Kulhavy November 16, 2008)

The argument I wish to make is that the assumption in IS that user-initiated innovation is propelled by unfulfilled user demand ought to be complemented with an awareness of the role played by political ideas. This assertion is congruent with the recent attempt by Siobhan O'Mahony and Beth Bechky to locate hackers in-between a community of user-innovators and a social movement (O'Mahony and Bechky 2008). Their approach supports the proposition that social movement theory is well equipped for analyzing both institutional and technological change. The reason for this is that bringing about change is exactly what social movements are all about (Davis and McAdam 2000; O'Mahony 2002). There is plenty of evidence in the history of science and technology to show that social movements have bred innovations and opened up new research avenues (Eyerman and Jamison 1991; Jamison 2006). For instance, the legendary Homebrew Computer Club was initiated by Fred Moore, who was also a pioneer organizer in the peace movement. The dream of building a small computer was an outgrowth of the small-is-beautiful philosophy in the 1960s counterculture (Levy 1984; Markoff 2005; Flichy 2007). Amateur radio is another area were tinkering with technology has intersected with political activism. The connection goes all the way back to the 1920s and the resistance produced by the transformation of the radio into a commercial, broadcasting media (Opel 2004; Horvitz 2008). The claim about offering an alternative media outlet is still entertained by "geeks" developing and transmitting amateur radio (Dunbar-Hester 2008). Likewise, in many cities in Europe, the first nodes in local wireless community networks were set up in squatted "social centers." Providing free Internet access was seen as a continuation of the larger agenda of reclaiming media from states and corporations. It complemented previous activities of printing "underground" newsletters, sending pirate radio, and broadcasting street-TV (Downing 2001; Atton 2004; Juris 2005). Likewise, the initial enthusiasm for wireless technology, in the Czech Republic and elsewhere, was fuelled by the promise of creating an autonomous, decentralized computer network that would be resistant to government eavesdropping, censorship, and surveillance (Myslik January

9, 2009). As is suggested by this non-exhaustive list, very many user-initiated innovations have developed against the backdrop of a broader, political engagement. This observation in itself merits a closer look at the social movements literature.

David Hess' work on "technology- and product-oriented movements" as an emerging trend among civil society organizations provides a good entrance point. These movements are less concerned with the politics of protest than with building alternative forms of material culture. The latter strategy often implies a symbiosis with private sector firms (Hess 2005). An advantage with this perspective on innovation is that it foregrounds different motives other than those typically discussed in economic theory. The question about the incentives and needs of the individual is here reposed as a question about the emergence of a political subject (Dubet and Thaler 2004). In accordance with much STS thinking, it is well understood that this subject is not predetermined but rather evolves through involvement and conflict. From this vantage point, a new twist can be given to the user as she has typically been postulated in IS literature. That is to say, a user with stable, although at first unfulfilled, consumer demands. My proposition is that this user is just one among several possible outcomes from the process by which the user community is being invented. The invention process is negotiated through competing technological designs, in the formulation of political standpoints, in the enforcement of community norms, and, crucially, in the creation of new markets.

Such an approach recognizes that the symbiosis between the user community and for-profit interests is often at the same time a point of contestation. An example hereof is the rift among hackers between the free software movement and the open source initiative. Although both camps encourage business models based on free/open licenses, they disagree over what role commercial forces should be allowed to play. Advocates of open source downplay political aspects and stress technical efficiency and the business opportunities of open source solutions (Berry 2004). Another example is Paul-Brian McInerney's study of the Circuit Riders, a group of activists promoting free software solutions for nonprofit organizations. Over the years, this group has come to position themselves against apolitical and more business-minded groups providing similar services (McInerney 2009). This is not to say that commercialization and the political aspirations of users always oppose each other. Commercialization can have multiple and partly contradictory effects that might simultaneously annul and expand the various political agendas of users. Arguably, the many garage firms selling services in connection with free software have increased the political clout of hackers

(O'Mahony 2002; O'Mahony and Bechky 2008). Still, it is often the case that when grassroots activists have succeeded in getting their technical solution adopted by the industry, later developments of the technology have been detached from any broader, political vision (Hess 2005). The activists might then find that their ideas are being marginalized by an ascending, pragmatic wing within the social movement and a rapidly growing, for-profit sector. This lesson can be learned from the recycling movement in the United States, which has given rise to a billion-dollar industry in waste management (Lounsbury, Ventresca, and Hirsch 2003). It is partly for this reason that I wish to problematize the tendency in IS literature of taking the creation of new market niches and the satisfaction of consumer needs as the end result of user-initiated innovation. When the issue is framed in this way, the many, conflicting visions that might have existed in the beginning risk being rendered invisible. In conclusion, when the ethical, aesthetical, social, and political rationales of user communities are renegotiated, following the attempts by some members to develop a marketable product, this process of commercialization should be located in a highly politicized force field.

The Origin of Ronja and the Czech Wireless Underground

A single Ronja link consists of two devices mounted in line-of-sight of each other. The main part of the device, the so-called head, is made from two chimney pipes. One pipe is equipped with a transmitter ("Tx") and the other pipe contains a receiver ("Rx"). The key component in the transmitter is a light emitting diode (LED). The diode was originally intended to be used in traffic signals. It operates in the red, or, in a modified version of Ronja called "Inferno," in the infrared end of the electromagnetic spectrum. The incoming light is registered by a photodiode placed in the receiver. The photodiode translates the pulses of light into electronic charges. In this way, the "blinks" of light are translated into the zeros and ones of a digital communication network. Ronja is able to send 10 Mb per second of data over a maximum range of 1.4 km. It is therefore much faster than WiFi transmissions on the 2.4 GhZ wavelength, which until recently was the only frequency permitted in the Czech Republic. The main drawback with the optical connection is that both red and infrared light are sensitive to fog. Apart from during bad weather and other interferences that block the line-of-sight, Ronja offers a remarkably stable means for connecting computers.

The Ronja project was initiated by Karel Kulhavy, or "Clock" as he is known among his peers. It was the remote control for the family's TV set, which first gave him the idea that light waves could be used to communicate at a distance. He made early experiments in 1998 before in 2000 starting to develop the idea more systematically. The first public version of Ronja was released on December 21, 2001 under the name Metropolis (Kulhavy November 16, 2008). From then onward, experiments with Free Space Optics took place in connection with a rapidly expanding movement of wireless community networks in the Czech Republic. Such movements emerged in many places around the world at this time (Hampton and Gupta 2008). Most wireless networks rely on WiFi technology that uses a small, unlicensed patch of the spectrum that has previously been deemed unsuitable for commercial and military purposes. When government regulators freed the unlicensed part of the spectrum, they intended it to be used by companies for in-house purposes, such as connecting computers in an office building or at trade fairs. It required some ingenuity to adapt the available equipment for the purpose of setting up outdoor, neighborhood computer networks (Oost, Verhaegh, and Oudshoorn 2009; Dunbar-Hester 2009). In the beginning, for instance, pineapple cans were widely used to create homemade antennas that directed the signal and extended the range of WiFi links (Snajdrvint December 14, 2008). The Czech Republic has seen an exceptionally strong growth of wireless community networks. According to European Union (EU) statistics, more than 35 percent of all residential Internet connections in the country are provided through wireless technology, which places it highest in Europe (COM 2009). In Prague alone, there are something like 250 independent wireless community networks. Some of these networks consist of just a handful of friends, other networks gather several hundreds or even thousands of members. The largest single wireless community network in the Czech Republic, administrated as a nonprofit organization, is found in the city of Plzen and has more than 8,000 members. The common forum for the wireless underground is the CZFree.net Web site. It was started in 2001 and has become the central node for discussions and collaboration between the many independent groups (Polak January 16, 2009).

When the first wireless community networks were set up, the price for one WiFi point was more than 700 euro. In comparison, the parts for building a complete Ronja link cost between 35 and 100 euro (Sykora November 27, 2008). In addition to the price advantage, free space optics has had many technical advantages. Price and performance came together to produce a soaring interest in Ronja. The official Web site boasts photos of 153 registered Ronja installations. The actual number of links, which have been built is likely to be much larger though. An indication hereof is given by Ondrej Tesar, a developer who began to distribute a key component in Ronja, the LED. Since the diode is shipped from the United States in packs of 120, he ordered large quantities and sold single diodes to members of the Ronja community. Tesar distributed more than 800 diodes and he confirms that wireless community networks in other cities in the Czech Republic ordered their own diode packs directly from the United States (Tesar October 5, 2008). It can be added that groups elsewhere had to figure out other means to acquire diodes. In Kerala in India, for instance, the diode that is specified in the official guidelines for Ronja is not available in the country. The design was therefore modified so that it could work with a replacement (Krishnan October 5, 2008). Based on Tesar's estimate and on accounts from distributors of other critical Ronja parts, it seems plausible to estimate that between 1000 and 2000 Ronja links have been built worldwide. Many of these links were used as backbones in wireless community networks. Hence, it is impossible to know the number of computer users that have actually benefited from the technology.

What has prevented a faster diffusion of Ronja is the demands it makes on the builder's skills and motivation. It will take an experienced user several days to assemble the electronics and more than a week to construct the mechanical parts. For first-timers, the whole process of learning how to build a Ronja link usually stretches over several months. Although many of the people who have built Ronja devices have had no previous experience with electronics, and quite a few of them were high school pupils when they first got involved, it is also the case that very many of these individuals ended up studying and working as engineers (Elias September 27, 2008). At the very least, a passionate interest in technology and an abundance of spare time is required to use Ronja. This has proven to be a rather discriminatory threshold in itself, as is suggested by the staggering absence of women in the Ronja project. In this respect, it does not appear that different from other hobby engineer projects (Håpnes and Sörenson 1995; Faulkner 2007). Equally problematic, given the stated aims of the project, is that the Ronja community is heavily skewed in respect of nationality. Most Ronja links have been built in the Czech Republic, with a sharp decline in its diffusion to neighboring countries in Central and Eastern Europe. Even in neighboring Slovakia, where language is not a barrier, far fewer Ronja devices have been built. The reason, according to one developer, is that "In Prague you had quite a lot of people who could actually help you with building Ronja"

(Hecko December 17, 2008). In sum, the lack of user communities in other countries where collective learning process could evolve and resources could be pooled slowed the transfer of the technology beyond the Czech Republic.

The Philosophy and Practice of Developing a User-Controlled Technology

In this section, I will present the philosophy of user control and discuss how this idea was negotiated in the Ronja project. Thereby, I want to foreground how a political vision arose out of and contributed to the innovation process that also brought about a free space optical device and a user community. On the official Web site, the Ronja project is declared as a "user-controlled technology." This notion is indebted to ideas circulating in the hacker movement and most clearly articulated by the Free Software Foundation. The advocacy of free access to the source code boils down to the recognition that without such access, someone else than the user is in control of the technology (Stallman 2002). This political analysis is coupled with an emotional and aesthetical investment in the technology. For instance, hackers often speak about the beauty of free software code and contrast it with proprietary "spaghetti" code (Chopra and Scott 2007). The novelty of the philosophy of user control is that these sentiments are extended to hardware development. Subsequently, the critique of intellectual property spills over into a critique of the dominant, industrial model of developing all kinds of consumer electronics. Such ideas are occasionally voiced on the Ronja Web site and in postings on the mailing list:

> In [a] commercial environment, the behaviour of the manufacturer is directed tightly by the consumers, so the manufacturer is forced to make crap, because [the] masses demand it. They don't even have to keep the design functional. If failure occurs in 1% of the devices, the consumers simply exchange [them] on a warranty, which is lawful, but costs them enormous amounts of time. Making the devices at more quality yields extra expenses and no revenue. (Kulhavy, Ronja mailing list, July 27, 2003).

In contrast to ordinary consumer electronics, the Ronja project has been conceived so that a lay user can understand the technology and build it himself. The first step to achieving this goal is that all the designs are published under a free license. Equally important, the device is constructed from generally available and relatively cheap components. Sometimes it required months of extra design work to achieve the same thing with an off-the-shelf part that normally would have been done with a special purpose component. For instance, commercial grade Free Space Optical devices use specially crafted, optical lenses to focus the beam. Ronja does the same job with an ordinary magnifying glass that can be bought in the flee market in Prague for a few Euro. Likewise, the electronics in the original design are based on components that are more than thirty years old (de Stigter September 30, 2008). Besides the additional hurdles with designing the device under these conditions, it has become necessary to provide instructions for building the device, which are comprehensible to a lay person.

More than in any programmatic statement, it is in these design choices and in the licensing scheme that the philosophy of user control is manifested in the Ronja project. This idea was crucial for motivating the extra work required for lowering the threshold of entry and diffusing the technology. My claim can be backed up by a comparison between the Ronja project and similar experiments with free space optics, which took place in the Czech Republic at about the same time. An example hereof is Petr Seliger's Cheapo. He made a simple device for connecting his friends' computers in the village where they lived. Once this need had been fulfilled, Seliger had no ambition to develop Cheapo further or to make it publicly known. When he learned about Ronja a few years later he switched to the more advanced design (Seliger October 21, 2008). This underlines the importance of the political vision behind Ronja for disseminating the technology and involving a collective of users in the development process. As was mentioned before, the wireless community in the Czech Republic played a decisive role in the reception of the invention. Similar observations have been drawn from the wireless community network in Leiden. The success of that project depended on that users pooled their heterogeneous resources (Oost, Verhaegh, and Oudshoorn 2009). One compelling reason for users of Ronja to cooperate was the incentive to work around the obstacles created by economics of scale. Most of the parts used in Ronja are normally sold to corporate clients and come in large quantities. The LED is just one example of how users joined together to reduce the price of various components. Space is another shortage that has fostered cooperation. Access to workshops and rooftops where Ronja links can be mounted have been shared between members of the community. Coordination of these resources, as well as help with finding bugs, and suggestions of places where components can be found have been organized through the Ronja mailing list.

More committed members of the Ronja community have helped out with numerous, nontechnical tasks. Some examples include the translation of texts between Czech, English, and German, proofreading and illustrating the guide for building Ronja, and responding to questions from "newbies" on the mailing list (Sykora September 27, 2008). However, if the philosophy of user control is judged by its own standards, it is noteworthy that few solutions to technical problems have originated from members of the community. The original design was authored almost single-handedly by the main developer, Clock. Although ideas from technically competent users were put forward, few of these suggestions made it to the official release. As Clock recalls, people added features without taking into consideration whether the modification would work for others and under different conditions. Alternatively, they did not devote time to writing instructions that could be understood by nonspecialists (Kulhavy September 16, 2008). The focus of the project on the requirements of inexperienced users frustrated many technically skilled users. The complaint of one former developer is characteristic:

> For the first-timers, who where at the beginning of their research about Ronja and how to build something and do things, Clock's approach was very good. Because Clock made lots of things easy to understand and build and to get the sense of it. But I think once people started to be more involved in hacking the Ronja and getting it better, or worse, whatever, just trying to put some knowledge into building the sense of the community, that was not very well accepted by Clock. (Hecko December 17, 2008)

Such clashes of expectations between users with different skill levels is common in free software projects too. It is usually resolved by parallel releases of the software. The Linux kernel, for example, has one stable version intended for ordinary users and one experimental version chosen by developers who chiefly want to play around with the code (Moody 2002). Experimental versions circulated in the extended Ronja community as well, but most of these modifications were not documented on the official Ronja Web site. The new designs spread by word of mouth in the thriving wireless network scene in the Czech Republic and in Slovakia. Even so, it is likely that most Ronja links that have been built in these two countries diverge in one way or another from the official guidelines (Sykora September 27, 2008). The original design prioritizes robustness and reliability. The drawback is that many details require a lot of effort to make. Hence, one compelling reason for making modifications has been to cut corners in the production process. This is particularly appealing to people who want to build several Ronja links at once. For instance, the chimney pipes used for the head are made from metal and weigh about 10 kilos. It takes many hours of drilling and cutting to create the final parts.

Afterward, it is necessary to seal the holes with silicon to prevent moisture from destroying the electronics. This toil can be avoided using plastic drainpipes instead. Although plastic pipes are not included as an option in the official guidelines, the modification have become very popular. Many other technical details have been changed for the same reason (Bohac September 14, 2008).

While there exist an abundance of variations on the mechanical construction of Ronja, far fewer users have felt confident enough to tinker with the electronics. However, a smaller number of skilled users in the extended Ronja community have also contributed to the development of the electronics. Early versions of Ronja were based on so-called airwire constructions. This means that the electronics were made from discrete components that had to be soldered manually onto a board. The undertaking was daunting to inexperienced users, it took a lot of time, and many things could go wrong in the process. Consequently, demand was building up for having the airwire construction replaced with printed circuit boards (PCBs). Clock was reluctant to take this step since he feared that it would diminish the self-reliance of the user. The PCBs had to be ordered from a firm and the economics of scale made it impractical and expensive to buy small quantities for personal use. The first PCB for Ronja was instead developed by Jan Skontorp and Ondrej Tesar. It took them about six months to get a working PCB prototype based on the schematics of the original airwire construction. Their board was released in 2003 and it was quickly adopted in the wireless community. Ondrej estimates that for about a year or two, it was the most widely used design option when people built Ronja links (Tesar October 5, 2008). Other prototypes followed and there might have been as many as four or five different designs of PCBs at one and the same time in circulation (Seliger October 21, 2008). Clock was eventually persuaded to provide an official version of Ronja, which included PCBs. He changed his mind partly because it had proved to be hard to write a guide for how to build the handmade electronics, which could be understood by lay users (Kulhavy September 16, 2008).

Most of the tinkering with Ronja by users has been customizations. Although some of these changes became very popular, such as the plastic drainpipes, the designs were rarely documented and did not aim for standardization. However, there have also been community efforts that could rightly be called research and development. From the outset, members on the Ronja mailing list have pondered over how to upgrade the 10 Mb/s Ronja link to a 100 Mb/s connection. The problem is that LEDs are inadequate for sending data at such high speeds. Although the job could relatively easily be done with lasers, the participants in the Ronja community were reluctant to take this step for reasons outlined in a posting on the mailing list:

> While a high-performance link can no doubt be built with specialized parts (in LFCSP or other non-DIY-friendly packages), I had the impression that one of the goals of Ronja is/was that it could be put together from simple, off-the-shelf components by people with minimal experience. It would be a pity to lose that. (Ronja mailing list, Bakker March 6, 2008)

There are several drawbacks with laser technology from the standpoint of user control. The laser is harder to aim than diodes since the diameter of the light cone is much smaller. Optics for a laser link have to be correspondingly more precise. As a consequence, the electronics and the mechanics must be assembled with a level of precision, which cannot be expected from anyone other than an expert. To the technical obstacles must be added the risk that the user will be permanently blinded by accidentally staring into the laser (Myslik January 9, 2009). In spite of the challenges, attempts to invent a faster connection were made by participants on the Ronja mailing list. It was in this way that Webjörn Gullik and Michael Elias found each other and started to work together. Since one of them lives in Sweden and the other in the Czech Republic, their collaboration had to be conducted through e-mail. They had some ideas for how to manipulate the LEDs to make them work faster. In this way they hoped that a high-speed optical link could be constructed without lasers. Although their experiments were partially successful, only a couple of diodes out of each batch endured the treatment. They could not know beforehand which diodes would burn since this property was not benchmarked by the manufacturers. Gullik and Elias failed, in other words, to stabilize the machine around any of the diodes that were available for hobbyists (Webjörn August 10, 2008; Elias September 27, 2008).

It is commonplace that free software projects give rise to conflicts over design choices (Pfaffenberger 1996). The Ronja community is no exception. The straightforward explanation for these conflicts is what hackers call the Not-Invented-Here syndrome. In other words, it boils down to squabbles over prestige and personal quirks. While this explanation probably carries some weight, it is more interesting to highlight the principles that are at stake. At one level, there seems to be tensions inherent in the very idea of a user-controlled technology. The commitment to making technology accessible to inexperienced users clashes with the pledge to engage a collective of highly skilled users in the development process. Furthermore, as was shown in the airwire versus PCB debate, the project came up against a trade-off between being accessible to a mass of ordinary users and the purity of the self-sufficient, DIY approach. There was also a trade-off in respect to functionality. The decision not to move from diodes to lasers shows that the principle of user control took precedence over the technical performance of the machine. By choosing not to pursue higher functionality at any cost, however, a vacuum was created, which was soon to be occupied by new initiatives. The tension between these new initiatives and the original Ronja project introduced a new axis of conflict. That is, friction grew between, on one hand, the philosophy of a user-controlled technology, and, on the other hand, the ambitions of many developers to create viable business models based on the invention. Many modified designs of Ronja aimed at taking the invention in the direction of industrial mass production, whereby the idea of having the user in control over the technology was abandoned.

Commercialization in the Extended Ronja Community

As the word about Ronja spread, there was an inflow of people who wanted the device but did not feel committed enough to build it by themselves. Experienced users started to receive requests to install Ronja for a fee. It is commonplace that long-term participants in the community have sold one or two links in this way (Elias September 27, 2008). This pattern is known from other user communities, where the process of commercialization starts with users becoming manufacturers producing goods for other users (Baldwin, Hienerth, and Hippel 2006). In line with this general development, some users began to sell Ronja in larger quantities. It is hard to estimate how many of these small-scale businesses there have been. However, the experiences from one town in the Czech Republic suggest that there were a large number. Chrudim lies in eastern Bohemia and has 25,000 residents. There have been three groups in the town, which independently of each other have manufactured Ronja for sale. One of these groups started in 2004 with four high school students. It took them a year to build the first devices for connecting their own four houses. In the meantime, they modified the mechanics so that units could be produced faster. In total, they built ten Ronja links and sold them for 550 euro each. Their main motivation was to have fun and they stopped the business when other hobbies became more enticing (Nemec December 14, 2008). Shops of the same, limited scale were set up in Pardubice, in Brno, in Prague, and in several other Czech cities (Elias September 27, 2008; Michnik December 17, 2008; Horky January 17, 2009).

The commercialization of Ronja was boosted by an emerging demand for the equipment among smaller Internet Service Providers. Firms in the lower end of the market began to use free space optics to deliver Internet connectivity to their customers. This growing demand was spotted by a small businessman in Chrudim and he started to experiment with a more ambitious business plan. He involved a member from the local wireless community network in Chrudim who had some previous experience with the technology. An Internet Service Provider commissioned them to build their first link and five employees were engaged to speed up the process. After a number of delays and disappointments, however, the technically experienced partner withdrew from the project. Reflecting on the failure, he suggested that there might be something latent in the design, which makes Ronja possible to build at home but impossible to produce for sale. The employees were simply not motivated enough to put in all the effort which it takes to get a Ronja link working (Kolovratnik December 14, 2008).

One of the founders of CZFree.net, nicknamed "Deu," had come to the same conclusion about the limitations of Ronja. Deu had set up a small workshop in his basement in Prague where Ronja equipment was produced and sold. The optical links were meant to connect the wireless community networks in the neighborhood with the Internet access point, which Deu was managing as a for-profit business. A regular visitor in Deu's basement was the engineering student "Lada" Myslik. He had built his first free space optical device as early as 1994. Soon Lada started to ponder over how to create what he called a "Ronja 100," that is, an optical link running at 100 Mb/s speed. After some disagreements with Clock, he decided to break with the Ronja project and start his own development project instead. His early trials with free space optics had taught Lada a few things about the technology, which in his opinion were missing out from Clock's project. He had realized that aiming was mission critical when designing a competitive, free space optical device. The time it took to aim a link had to be reduced from a couple of hours to a few minutes. This was not an issue for Clock since he intended Ronja to be used by amateurs who were short on funds but had plenty of free time. In contrast, Lada targeted business clients. He realized that the overhead costs for using Ronja were considerably higher for a company than for an individual. The company had to pay two employees for every hour they spent on the roof aiming the link. This difference in perspective between Clock and Lada was also behind their diverging viewpoints on how the device was best assembled. Lada's first assignment in Deu's basement had been to help inexperienced users to assemble their Ronja machines and find bugs. It was a frustrating experience which convinced Lada that he wanted a product that cuts the amateur out of the loop. Instead, he wanted a design suitable for industrial mass production so that the diffusion of the technology could be speeded up. Clock's vision about involving lay users in building the technology collided with Lada's main objective, to use the optical device for establishing a decentralized, wireless community network (Myslik January 9, 2009).

A venture was set up consisting of five people with Deu in charge of the management side and Lada heading the development team. The first prototype made by Deu and Lada was released in 2003 under the name "Crusader." Early versions of Crusader looked rather similar to the original Ronja device. It was based on LEDs and the mechanics were identical with Ronja. The major difference between them was the electronics. At that time, the official version of Ronja was still based on airwired constructions that had to be soldered by hand from discrete, electronic components. In Crusader, as well as in modified, "unofficial" versions of Ronja, the electronics were assembled with PCBs. Thus, Crusader was brought one step closer to the goal of being a mass produced, consumer good. In the first batch of production, the Crusader team made sixty devices and sold them for 1,100 euros a piece. This provided them with sufficient funds to pay for a second round of development. Unfortunately, a lot of the money was lost in bad investments and the group broke up shortly afterward. Lada and one other member from the original team continued to develop the next generation and their first prototypes are currently being tested in Prague. The technology is based on lasers instead of LEDs and operates at 100 Mb/s speed. The device is now working, but Lada is still struggling with getting the design to a stage where it can be conveniently mass produced (Myslik January 9, 2009 and January 16, 2009).

Disputes over Proprietary Forks of Ronja

The announcement of Crusader on the CZFree.net mailing list sparked off a row between Clock and Lada and their different supporters. At the center of this dispute was the refusal of the Crusader team to disclose all the details about their technology. Lada began to keep information secret after someone else had reverse engineered his design and incorporated it into a competing, commercial product (Myslik January 9, 2009). There were numerous other attempts in the Czech Republic, as well as in other countries in Central and Eastern Europe, to create proprietary forks of Ronja. According to one developer, who regularly publishes his own hardware designs on the Internet, this is the rule rather than the exception:

> When you have [an] open source and open hardware project there is sometimes coming another guy that is taking everything, he is making some very

> useful modifications for others, but he is not giving it back to the community and he is using it only for his own business. (Simandl October 27, 2008)

The Free Software Foundation drafted the GPL to address this problem. Software licensed under GPL can be copied by anyone and used without restrictions, on the condition that any derivation of the work is also shared under the GPL. Ronja was published under a version of the GPL drafted for documents rather than software code. Clock accused the Crusader team of violating this license. He insisted that since Crusader was a derivation of Ronja, all information about the technology should be released (Kulhavy, Ronja mailing list July 20, 2003). However, the purely legalistic arguments about respecting the GPL are founded on a deeper concern for the user community. The warning issued in much IS literature, namely, that users will grow reluctant to share information with each other, if a milieu becomes too competitive, is confirmed by the current decline of the Ronja project. One old-time developer of Ronja laments that secrecy and suspicion overtook the community. Over the years, it became successively harder to find collaborators for experiments where the results were going to be openly published (Elias September 27, 2008). The Ronja mailing list provides plenty of evidence of the same trend. Conflicts flared up over postings where someone claimed to have made a breakthrough but refused to give any details about his discovery. Development of Ronja has now come to a near standstill. Energy is instead being channeled into proprietary forks of free space optics. According to one estimation, from a person who is working on a 100 Mb/s optical device called "Cyclope," there might be three or four similar projects underway in the Czech Republic. No one can know for sure, however, since people nowadays are secretive about their projects (Kamenicky December 4, 2008). In the meantime, commercial WiFi technology has caught up with Ronja in price and performance, and, consequently, most users have lost interest in building the device (Hecko December 17, 2008).

In addition to the negative impact on the user community, I would like to direct attention to a point stressed in the philosophy of user control. On an individual level, due to the fact that the inner workings of the device are hidden away from users, their relation to the technology is transformed. This observation connects to the aesthetical and emotional element mentioned before, as is suggested by the following quote:

> I think we should drop 'the commercial product is better than the free hardware/software because it's cheaper/has lower TCO/has better features' and start asking 'and how is it with emotions?' (Kulhavy, private mail, September 28, 2008).

The appeal to emotions might sound startling at first. However, what stands out in the interview material are the claims by users to have developed a special feeling for Ronja. One user claims that the first time his Ronja started to work after weeks of tinkering was the most exciting moment in his life (Hecko December 17, 2008). Another user continued to run his free space optical link for nostalgic reasons long after his tower block had been furnished with a much faster optical cable (Kolovratnik December 14, 2008). These testimonies speak of a highly gratifying and emotionally charged relationship with technology, which has been registered in other hobby engineering communities (Kleif 2003). Most telling is perhaps the comment from a user who happened to have both a Ronja and a Crusader link running in his attic. He expressed the difference between the two machines as follows:

> I'm happy each time I see Ronja, this [pointing at Crusader] is just another networking device. (Bohac September 14, 2008)

The statements above might seem to be beside the point. It certainly was to those who mainly where interested in building wireless community networks. Plenty of requests for improving Ronja had been overlooked by Clock, sometimes because the modifications were incompatible with the principle of user control. By comparison, the first generation of Crusader was much easier to aim than Ronja and the team promised to soon deliver a 100 Mb/s link. Most members of the wireless scene had no desire to tinker with free space optics. Hence, they did not mind that the Crusader team was secretive about the development process of the device. Secrecy was the trade-off for higher functionality and more convenience. When these are the important criteria by which the technology is assessed, the difference between Ronja and Crusader is narrated as one between amateurism and professionalism. Lada recalls the dispute accordingly:

> [Clock] still wanted ordinary people to be able to manufacture their own Ronjas. He didn't want to go my route, he didn't want to go the manufacturer route, he wanted to stay on the amateur level, which I abandoned. I didn't want to be an amateur or let other people mount Crusader. (Myslik January 16, 2009)

One might wonder why the free software community has been relatively successful in sustaining its information commons despite a high degree of professionalization, while the extended Ronja community has proved to be less capable in this respect. An obvious factor is the different kinds of "resistance," which a hardware object puts up compared to software code in a collective development project. This difference between hardware and software is inscribed in the legal arena. The enforceability of the GPL rests on copyright law, which protects artistic and literary works, including software. Other kinds of invention fall under patent law. Although the design and schematics of Ronja were protected under copyright law, and, subsequently, under the GPL, this protection did not extend to the ideas behind the technology. Clock therefore lacked the legal means to enforce the license against people who he considered to be stealing his ideas without disclosing their modifications to the community.

However, one of Siobhán O'Mahony's conclusions from her study of free software projects is that the norms of the community are more important than the legal documents when it comes to sanctioning violations against the information commons. With this insight in mind, it is interesting to learn that members of the extended Ronja community felt less compelled to share information about hardware design than about software code. The quote below comes from an administrator of the nonprofit, local wireless network in Chrudim. He starts out by declaring that he is a fan of free software and never uses proprietary applications as a matter of principle. Then he continues by saying:

> Free hardware, for many people it is not a moral issue because they are not able to build it themselves and they usually do not have to accept twenty pages of license [agreement] from hardware vendors. Just buy it and have it, you can give it to anybody. From my point of view it is not such a strong moral issue. It is nice that people can build it, but I think it is different from the software issue. (Zajicek December 14, 2008)

Worth taking notice of in the quote above is that the argument turns around the difference in restrictions, which are imposed on the user of proprietary software compared to a user of a hardware device. This assessment is formulated from the viewpoint of the individual user. However, it reaches outward to link up with a broader concern over political freedoms and privacy issues, all of which belong to a more general critique of intellectual property rights. Commitment to those values plays a central role in the mobilization of developers in free software projects (Elliot and Scacci 2008). Richard Stallman, the founder of the Free Software Foundation, never misses an opportunity to speak about the political ramifications of sharing software code. On the question if the same analysis applies to free hardware, he has responded negatively. Like the administrator of the wireless network in Chrudim, Stallman stresses that software is fundamentally different from hardware (Stallman 1999). The philosophy of user control tries to extend the critique of proprietary software development to include the industrial mode of developing all kinds of technology. As it turns out, however, only a fraction of the extended Ronja community has been persuaded by that argument. Perhaps, this failure explains why the obligation to share information about hardware designs is not felt to be such a "moral issue." If my observation is correct, it strengthens the hypothesis in this article that there is a link between the norms of the community and a normative standpoint, anchored in a wider, political analysis. This in turn points to the importance of a shared vision and a common, political cause for enabling a milieu in which collective innovation can thrive.

Conclusion

This article has argued that normative standpoints should be weighted in as an element of user-initiated innovation. It has been suggested that when there is a political cause for users to rally behind, this can strengthen the norms of the community that compel its members to share information with each other. The willingness to disclose information has been previously shown to be a precondition for collective innovation processes. Hence, it seems plausible that political ideas can play a role in fostering user-initiated innovations. The same conclusion is supported by the long list of user-initiated innovations that have originated in social movements. David Hess' concept of Technology—and Product Oriented movements, and Siobhán O'Mahony's work on free software development communities, both point toward a convergence between social movements and user communities, both theoretically and practically. From this angle, the creation of new markets and the starting up of garage firms are not the end purpose of user-initiated innovation. At least in the eyes of one fraction of the user community, a symbiosis with for-profit interests is rather seen as a means toward furthering some other, political cause. It follows that such alliances are not always cordial but more often the subject of heated negotiations and internal strife.

The Ronja project underlines the friction that can arise between the norms of the user community and the commercialization of the technical product, both arising from the same innovation process. When the user-initiated innovation is refined into a consumer product, the values of the user community might be simultaneously transformed by the crystallization of consumer relations. This argument has been pursued as a critique of the tendency in IS literature to take the needs of mature user communities and the corresponding technical functions of products as a given. As Ellen van Oost, Stefan Verhaegh, and Nelly Oudshoorn have argued before, the IS literature gives insufficient attention to the possibility that users and their motives may be transformed in the course of the innovation process. Without an awareness of this possibility, it can easily appear as if the only noteworthy change happening in the user community is a linear improvement of the functionality of the product, which better approximates user demand. I have proposed that such an outlook risks projecting backward the conditions found in the mature user community. As a consequence, other points of view, which might have been present in the user community at an earlier date are rendered invisible.

Had this article been framed in such a way, it is plausible that the Ronja project would have figured in the margins of a study culminating in a firm with a commercial-grade free space optical device. What would have been missing out of such an account is the recognition that the Ronja community did not simply fail to meet the demands of consumers, in particular to upgrade their device from 10 Mb/s to 100 Mb/s speed. The decisions to stick with airwired constructions instead of PCBs and LEDs instead of lasers were anchored partly in politically informed ideas and partly in an aesthetical investment in the technology. These sentiments come together in the philosophy of a ‘‘user-controlled technology.’’ The importance attested to the rights of users to have control over the technology they are using resembles the advocacy for free software. However, by applying the idea of user control to hardware, the Ronja project extended the critique against proprietary software development into a broader critique directed at the industrial mode of developing all kinds of consumer electronics. It has been suggested that the failure to reach a consensus in the extended Ronja community on this matter contributed to the failure to enforce the norms concerning the sharing of information about hardware designs. This supports the central claim made in the article; namely, that normative aspects can be important for inducing user-initiated innovation processes.

Appendix

Bohac, Jiri, contributed mechanical inventions for Ronja, user of Ronja (Prague, September 14, 2008).

Elias, Michal, experimented with Ronja design, vendor and user of Ronja (Prague, September 27, 2008).

Gullik, Webjörn, experimented with Ronja design (phone interview, August 10, 2008).

Hecko, Marcel, developed PCB for Ronja, administrator of a nonprofit, wireless network, user of Ronja (Bratislava, December 17, 2008).

Horky, Jakub, vendor of Ronja (Prague, January 17, 2009).

Hudec, Jan, tested the first versions of Ronja (Prague, December 8, 2008).

Kamenicky, Tomas, developer of a second generation of free space optics (Prague, December 4, 2008).

Krishnan, Arun, developer and user of Ronja in India (telephone interview, October 17, 2008).

Kolovratnik, David, user of Ronja (Prague, December 14, 2008).

Kulhavy, Karel, main developer of Ronja (Zurich, November 16, 2008).

Michnik, Jakub, vendor of Ronja (Brno, December 17, 2008).

Myslik, Lada, main developer of Crusader (Prague, January 9, 2008).

Nemec, David, vendor of Ronja (Chrudim, December 14, 2008).

Polak, Michael, running an Internet Service Provider, user of Ronja and Crusader (Prague, January 16, 2009).

Seliger, Petr, developed PCB for Ronja, user of Ronja (Prague, October 21, 2008).

Simandl, Petr, administrator of non-profit wireless network and independent developer of open hardware designs (October 27, 2008).

de Stigter, Johan, running a company selling wireless equipment, sponsor of Ronja (telephone interview, September 30, 2008).

Snajdrvint, Karel administrator of a non-profit wireless network, user of Ronja (Chrudim, December 14, 2008).

Sykora, Jakub, user of Ronja (Prague, November 27, 2008).

Tesar, Ondrej, developed PCB for Ronja, distributed light diodes, user of Ronja (Prague, October 5, 2008).

Zajicek, Ondrej, administrator of nonprofit, wireless network, user of Ronja (Chrudim, December 14, 2008).

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Bio

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