From Simple Customer to Warm User: Who Cares about the Maintenance of Community Innovations?

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Abstract

This paper arises from ongoing research into user-initiated community innovation. Empirically, it builds on a case-study of the Dutch Wi-Fi infrastructure *Wireless Leiden* (WL), created in 2001 by local residents as a communicative assemblage of cheap consumer devices, home-built antennas and open source software (Author, Forthcoming). As the innovation is produced by a grassroots, bottom-up volunteer collective it is lacking financial resources for conventional repair and support services. This then raises the following question: how is support of users and maintenance of technology organized and arranged within community innovations? The argument developed, is that community innovation can only succeed by creating a socio-technical infrastructure of support, often but not exclusively, based on informal economies. Stabilization of community innovation can be understood as the successful mobilization of non-innovating end-users performing maintenance work. To 'give voice' to the often invisible work of end-users, I introduce the notion of warm user resembling the warm expert (Bakardjieva 2005). Whereas warm experts help inexperienced users to properly connect to network technologies, warm users help novel technologies to properly connect to user collectivities. I conclude with a reflection on the broader importance of maintenance work performed by warm users.

Key words: Community innovation, Wi-Fi, maintenance work, attachment to technology, warm expert, warm user

Prelude

Leiden, eight o'clock PM: an ordinary working day evening in a middle-sized town in the Netherlands. While it is raining outside, inside their houses most inhabitants are loading their dishwashers after their evening meals, watching news on their television sets, or reading bedtime stories to their children. However, on the deserted streets, a solitary character protected by a waterproof suit is quickly cycling towards the 'Hooglandse Kerk', one of the old churches that grant the historical city-centre of Leiden its picturesque quality. His aim is not to seek shelter from the rain, to enjoy the meditative silence, or to attend divine service. For that would be impossible at this hour of the day, when the church is closed to the public. After borrowing the church key from the nearby-housed sexton, he accesses the building through one of the side entrances. Inside, he walks straight up the narrow and creaky stairwell that grants entry to the most upper part of the bell tower. Once arrived on the bell platform he switches on his torchlight enabling him to locate

the aim of his trip: three brightly-yellow painted military ammunition boxes connected by heavy duty cabling to artfully camouflaged aerials which from a distance are only barely discernable from the sandstone tower walls. Carefully he opens the three yellow boxes to reveal their inner secrets. From his coat pocket he grabs an electronic scheme showing the functions of the various cables and buttons. The heading of the form states 'Debugging checklist node Cetim'. After reading the description, the man presses some buttons, watches some LED lights switching on and off again and compares their status with a description on his scheme. After a few minutes the devices seem to have been properly restarted. Mission accomplished; time to go home. The man descends the stairway, switches off the church lights, carefully closes the church door behind him and returns the key to the sexton.

(To be continued...)

Fig. 1 Wireless Leiden node Cetim located in the Hooglandse Kerk[1]

[1] Source: http://svn.wirelessleiden.nl/svn/node-config/fotos/CNodeCeTIM/foto/setup/tn/

Introduction

To be able to understand what the yellow contraptions (fig. 1) are we first need a short introduction of outdoor Wi-Fi networking in general and Wireless Leiden as an exemplary case of this global user-initiated phenomenon in particular.[2]

First a short note on the history of outdoor community Wi-Fi initiatives. After the IEEE introduced the 802.11 wireless networking standard in 1997, it would not be until Apple introduced its sub-hundred dollar Airport-card, based on the so-called 'b' version which by now was referred to by the more consumer friendly name Wi-Fi, that this novel technology arrived at what Cowan (1987) has termed the 'consumption junction', or the price-point, place and time at which technologies become interesting enough for consumer to consider to start using. Originally this technology was explicitly designed to function in indoor environments as an invisible replacement for short-distance Ethernet cabling. However, soon after its introduction users experimented with unforeseen uses in outdoor environments to establish long-distance, point-to-point wireless links. Although commercial equipment was already available for this purpose, it was prohibitively high priced ($10.000 and up), and it only operated on frequencies, which had to be bought from the government against again prohibitively high prices. In short: not to be used by consumer users, but only by big telecommunication companies. However all that changed with the advent of cheap Wi-Fi which allowed for free use of the wireless 2,4 gigahertz band. Soon people exchanged information on Internet on how to adapt devices to be able to span distance of kilometres instead of meters. All over the world small groups of Wi-Fi enthusiasts initiated projects to build wireless networks, both in cities as well as in rural areas. Most of these initiatives remained relatively small in size and scope, however some of them, for example the Djurslands.net initiative in Denmark, evolved into the only available infrastructure over which broadband Internet access could be delivered, because commercial Internet providers could not do this in a profitable way.[3] Another example of an innovative initiative is Wireless Leiden, which also brings us back from the history of outdoor Wi-Fi networking to the yellow boxes from the prelude.

Wireless networks are built of interconnecting nodes. The yellow boxes are examples of the physical appearance of the nodes that together form the backbone of a wireless infrastructure covering almost the whole of Leiden. In the case of Wireless Leiden, this outdoors Wi-Fi network is built by volunteer hobbyists out of consumer-grade Wi-Fi equipment, open source software, homemade aerials and all this in various location-specific homebrew configurations. The network is built of nodes that consist of computer hardware,

[2] In my research project, I choose the approach of an explorative, in-depth case study (Yin 1984) because no previous studies described the dynamics of emerging Wi-Fi community initiatives. In order to improve reliability of the results, triangulation of empirical data was obtained by harvesting different sources (Eisenhardt 1989), while 'following the actors' (Latour 1987) both online as well as offline. First, I explored the publicly accessible Wireless Leiden website, wiki and repository (http://[www; wiki; svn] .wirelessleiden.nl). This site proved to be a tremendously rich source, as – in the traditions of open source communities – full transparency is strived for at both material as well as organizational aspects. Minutes of meetings, discussions and debates were made available online in addition to technical descriptions, guidelines and images. Second, I explored the members-only archives of the volunteer mailing list. Third, I held in-depth interviews with different actors ranging from core initiators of WL to peripheral end-users. Four, I visited WL meetings visited between January 2005 and April 2007. At these meetings I observed discussions, presentations and workshops and I interviewed additional participants or potentially interested attendants.

[3] For more information see: http://www.djurslands.net

running software that routes data packages wirelessly through the air from one node to another. The size and complexity of this network is globally unique, as well as the degree of involvement from local government, corporate sponsorship and municipal support. Although the initiators built the wireless network as a general-purpose data network, many local Leiden inhabitants developed an interest in getting connected the moment free gateways to the Internet were introduced. Most local residents thus understand Wireless Leiden primarily as 'free access to the Internet', although functionality in this regard remains limited to connecting to the World Wide Web section only.[4] Although there is much more to be told about all the specific ingenious technical and organizational solutions that needed to be invented in order to make it all work, I will not do that in this paper, because the WL builders themselves already described it clearly and concisely (Van Drunen et al 2003). What suffices for the purposes of this paper, is to understand WL as a user-initiated 'community innovation' (Author, forthcoming 2008).[5]

To return back to the mysterious man from the prelude, he himself also has no more knowledge of the intimate delicacies of the inner workings of the Wi-Fi nodes than the reader of this paper. The only thing average WL users know is that their own computers are connected wirelessly to one of the nodes. In the case of the man from the prelude, 'his' node is located in the church tower. Although most the time it all works 'transparently', that means the technology in-between 'fades away in the background', sometimes it stops behaving correctly. Suddenly the wireless technology is at the centre of focus, because without it, the connection to the Internet simply stops working as well. However in the experience of those with hands-on experience of power-cycling WL nodes, often with a simple press on a button, without further knowledge of all the magic involved, it simply works again, usually for weeks or months in a row. But how did this curious practice of people walking up and down church towers in order to reboot complicated homebrew hardware devices develop? In order to be able to tell that story, first we need to get a clearer understanding of all the actors currently involved in supporting Wireless Leiden.

A tentative typology of support for Wireless Leiden

In relation to how support is organized in Wireless Leiden we can distinguish two different types of support, in the first place for people who want to connect, and in the second place support for maintaining Wi-Fi nodes. First, support for people who want to connect to Wireless Leiden is arranged as follows. In the most simple scenario, installation service is provided by the shop owner who sells commercial packages that

[4] In technical terms: only traffic on TCP port 80 (http) and 443 (https) is allowed access to the Internet through three proxies connected to three ADSL connections donated by a Dutch ISP.

[5] Recently, publications have started to explore the emerging phenomenon of Wi-Fi community initiatives (Rheingold 2002, chapter 6; Rao and Parikh 2003; Medosch 2004) or the innovative use practices of Wi-Fi (Escudero-Pascual 2003). However, only Sandvig (2004) focused explicitly on community Wi-Fi as a locus for "diffusion, experimentation, innovation, popularization, and the provision of new features and services".

enable reception of the Wi-Fi signals. Investments in hardware usually range from somewhere between 25 euros for a simple USB Wi-Fi stick, up to 250 euros for a weatherproof and foolproof Wandy client. Additional support can be acquired to the Wireless Leiden user mailing list, where other users answer questions. People who prefer face to face support can go to the weekly 'help desk' evening, where official WL volunteers help potential users to get a working connection. In the case of persistent problems, sometimes an on-site visit at the users' home by an experienced volunteer can be arranged through the WL mailing list. My own observations have also shown that end-users mobilize support from 'knowledgeable' friends, neighbours or colleagues who are not necessarily involved with Wireless Leiden, but are nonetheless perceived as knowledgeable 'computer folks'. An unrelated forum website called "Wireless Nederland" also provides free user to user assistance on outdoor Wi-Fi related problems.

Second, support in the form of maintenance of the involved Wi-Fi devices depends on the type of device, its importance to the network as a whole, and its owner. End-users are supposed to care of their own connectivity devices. In the case of an expensive Wandy, it is usually so thorough that no maintenance is necessary at all. In the case of important nodes that are owned by official WL volunteers, the owner usually takes care of maintaining it. However this leaves a third category of nodes as a problematic category: namely important nodes, with many connections to other nodes, which are placed strategically on high buildings such as church towers. Usually corporate sponsors pay for these nodes, although ownership ends up in the hands of the Wireless Leiden foundation. The technical experts who build these nodes are primarily interested in constructing new things. Repairing them in case of breakdown, is seen as a much less rewarding 'routine' task. This causes a problem for the stability of the network as whole, because especially these bigger nodes, due to their increased complexity, are often characterize by their fragility when it comes to failures. Sometimes it takes days before volunteers are notified that nodes are malfunctioning, and then again it takes days before anyone finds the time to go to the physical location to actually fix these nodes. Financial resources to 'hire' professionals to fix the nodes are lacking, and even if these were available, it would not fit in with the volunteer character of the organization. This leaves not only the reader but also Wireless Leiden as a whole with the question of how to arrange the maintenance of these important but often neglected nodes.

Wireless Leiden as technical hobby community

In order to better understand why 'official' WL volunteers on the one hand like to construct 'exciting new stuff' but on the other hand seem to be not really motivated to perform maintenance work, the notion of 'technical hobby community' (Haring 2007) offers a useful perspective. In order to get a feeling of the type

of persons that literally make WL one would only need to attend one of the monthly WL meetings. A cross-section of the WL volunteer community is given by the photograph in figure three, taken during one of the many get-togethers. However, looking at the case exclusively from the people point of view, nothing really interesting shows up; just a bunch of people having a drink while chit chatting about their technical hobby. The only thing that seems remarkable is that women are almost completely absent. However this is business-as-usual for communities focusing on self-building of technology, in which control over technology seems to serve as a way to construct a male gender identity; for a case-study on automobile tinkering see Kline and Pinch (1996), for robot building and software engineering, see Kleif and Faulkner (2003), and for radio technology see Douglas (1987), Haring (2003) or Dunbar-Hester (2003). However, the central focus of this paper is not the gender politics of community innovation; that would be another paper all together.

Fig. 2 Wireless Leiden community: coffee break during meeting in local community centre (Leiden, 2 November 2003) (source: website Wireless Leiden).

Haring (2007) introduced the notion of technical hobby communities in the context of her research on the technical culture of American radio amateurs from the 1930s to 1970s. She described these men as precursors to the group of computer hackers, which would emerge somewhere in the seventies and subsequently with the advent of the Internet grew increasingly larger. What is characteristic for these technical hobby communities is that the boundaries of their social group are quite clear in the sense that

either someone is a technical hobbyist, and therefore group member, or someone is not. The community thus homogeneously consists of 'hobbyists' who all own the 'type X' device that is at the heart of the hobbyists' interests (e.g. radio, or motorcycles or computers) combined with an enthusiastic passion for engaging with it in an avocational manner.

Following this line of thought, WL could be understood as consisting of an enthusiastic group of people with a passion for tinkering with computers and wireless devices, working towards realizing a shared goal of building a local wireless computer network. Initially there was no formal organization, no name nor a corresponding website, just enthusiasts meeting each other in the evenings in their homes to collectively engage in some 'Wi-Fi hacking'. The collective tinkering with technology by solving practical engineering puzzles while simultaneously drinking some beers provided a means for creating a shared identity as well as a sense of belonging to a social group of local 'computer enthusiasts'. So we can understand WL in its infancy as a technical hobby community, of which there are many more examples such as automobile or motorcycle enthusiast, radio amateurs, radio-controlled miniature airplane hobbyists or more generally 'brand Y' or 'type X' device user groups. In the same way as many hobby communities became institutionalized through associations on a national or even international level and bounded by government through certain regulations, the non-profit association Wireless Leiden was formed as an official legal person. Additionally membership by signing a volunteer contract was introduced. In this way the core group of 'official volunteers' could be understood as a technical hobby community.

However in later 'phases' of its development, particularly starting at the moment when free Internet became available and an increasing user base emerged, WL can no longer be described in terms of a technical hobby community.

In the first place, what sets apart WL from a 'standard' technical hobby community is the strategy to actively enrol people with no interest in the technology itself, but interested only in the possibilities these technologies open up. In the WL case the initiators came up with the 'free Internet' carrot to seduce people to connect to the WL infrastructure. This way Wi-Fi no longer had to be seen as an interesting goal in it self, but rather as a means for accomplishing other uses such as obtaining free access to a fast connection to the World Wide Web.

What sets apart the WL case in the second place, is that although the initiative started as a close group of *tinkerers* with a strong interest in Wi-Fi technology, from the onset on the group consisted of people with increasingly diverse backgrounds and thus also a much broader interest than only being interested in technology alone. From the outset in 2001, the WL group could be described as a mixture between those with an interest in computers combined with people with an interest in radio. What they shared was an interest in using technology to create digital communication networks. Although technology itself is still

seen as an important topic, for the WL project to succeed as a whole, many more 'softer' social skills and expertise are becoming increasingly important, such as dealing with the press, interesting sponsors, assisting end-users, organizing volunteers, etc.

For many participants in Wireless Leiden, being a member of a community of tinkering with Wi-Fi, becomes part of their identity. They obtain a 'sense of belonging' from being part of a community of creative do-it-yourself technical enthusiasts; in particular because they realise that with their active involvement, the technical infrastructure would quickly decay into a non-working state. In this sense the direct messages sent between volunteers when they drink a beer together are equally important for the 'correct' functioning of the network as digital data packages sent between different Wi-Fi nodes.

In relation to this servicing of a 'public' the members of the WL community can be seen as a kind of socio-technical *bricoleurs* (Lévi-Strauss 1968) creating a local Leiden 'communicative assemblage' (Slater 2006). Currently, Wireless Leiden consists of a broadband Wi-Fi 'freenet' ("Wireless Leiden") made up of 69 Wi-Fi nodes, around 90 volunteers, free access to the World Wide Web (sponsored by a commercial ISP) and a few thousand Leiden citizens using WL to mainly browse the web and e-mail. The exact number of end-users is unknown because access is 'free' and 'official' registration procedures are lacking.

In the case of community innovation both people and technology are 'fluid' and exactly this 'fluidity' instead of stabilized black boxes creates the possibility for a sustainable state of the 'network' as a whole (De Laet and Mol 2000). Where Latour describes the construction of 'immutable mobiles' in order to obtain 'stabilization', I will argue that in community innovations a sustainable degree of stability is actually obtained by keeping things open in a fluid manner. This fluidity through openness as organizing principle is visible in many different places. In this sense the fact that end-users are expected to actively engage with both the 'WL community' as well as the 'WL technology' is what creates the surplus value to choose for Wireless Leiden and not for an analogous commercial alternative.

The interesting thing is that this main organizing principle can be found both in the inner workings of the 'community' as well as in the inner workings of the 'technology'. The network as a whole consists of a whole of more or less loosely coupled elements that together make up the actor-network. In this sense nobody has a 'complete' overview of the 'network'. Depending on the position of the actor in the network the perspective causes another view. For end-users trying to connect to WL for the 'free' internet the network looks completely different than for the programmer located in Boston who as part of his after-work relaxation is tinkering with the optimization of the routing algorithm in the obscure 'OCaml' computer language.

In traditional actor-network literature there is always the implicit notion of the Machiavellian 'project champion' who as a spider in the web is controlling/seducing all the surrounding actors to do exactly as he

(because it is almost always a male protagonist) has planned.[6] Although politics and conflicts play an equally important role in community innovations, the centre of gravity is not lying in the centre, but it is distributed over many local small centres that constantly fluctuate in relevance. When I first approached WL volunteers in 2005 I asked them to sketch out the organization structure. What I had expected them to do was to sketch a small inner circle of 'enthusiastic experts' surrounded by a larger circle representing a group of less technically skilled 'volunteers'. However, most participants came up with several small circles of which some interconnected, while others were not. Communication between the different groups was sometimes completely ad-hoc, and sometimes heavily structured. However, according to those involved initially there was no 'whole' representing the complete Wireless Leiden, and secondly there was neither 'centre' nor 'periphery'. Admittedly some people were more skilled towards the technical spectrum; however those with good social skills were also broadly regarded as delivering equally important contributions. Most highly regarded were those who could navigate through technological and social challenges simultaneously, or as one of the participants said: "We have some people that can play chess many different levels at the time, and these people are the ones who really bring this project further."[7]

[6] For an overview of criticism on the 'executive approach' of ANT, see Oudshoorn and Pinch 2003:7 and Star 1991:29.
[7] Interview Gerard Mourits (SV-Todo: insert specific date)

Fig. 3 On top a 'volunteer' node with two long-range directional at the base and one omni antenna on top; below a 'user' node consisting of a commercial Wandy client-device. Note the differences in the size and complexity of the Wi-Fi configuration to connect to Wireless Leiden. (source: website WL, 2007).

Partial connections and invisibility

In the previous paper on Wireless Leiden (Van Oost et al 2007) the focus was mainly on the emergence of Wireless Leiden. Its main protagonists were the 'lead users' (Von Hippel 1986) who translated consumer-grade, indoor, cable-replacing, access point Wi-Fi devices into professional, outdoor, infrastructure, backbone-link equipment. In this paper my aim is to understand what happens *after* highly involved actors have developed their invention into something useable that then becomes attractive to a larger and more diverse group of users not primarily interested in technology for its own sake, but rather interested in actually using it in their everyday life. Or put more generally, how can we understand the stabilization of community innovations once they are 'up and running'?

In the previous paper we used actor-network theory[8], or more shortly ANT, as the theoretical framework to be able to describe the various types of work the initiators had to undertake in order to 'heterogeneously engineer' different types of elements together into a working whole. What made ant so useful, was that it allowed me to flatten different type of relationships. This *a priori* symmetry between different types in relationships is a good thing, for it allows the analyst to 'follow the actors' wherever they go, regardless from disciplinary domain, whether 'social', 'technological', 'economic' or 'political'. To be able to follow the protagonists thus also requires an analytical frame that is equally flexible. Actor-network theory in that regard proved highly valuable to be able to describe the work of the 'network' builders that initiated Wireless Leiden.

Let us return to the scene from the prelude. Whereas the protagonists in the previous paper on Wireless Leiden were quoted by name, or meet each other during meetings, the solitary 'button-pusher in the church' is anonymous. We do not know his name. This is not by accident, neither a stylistic choice of the author of this paper. It is on purpose, because also in Wireless Leiden this man is not as deemed as important as the original initiators. Although the person from the example by now has officially become a volunteer, his picture named 'anonymous.gif' on the webpage listing the volunteers displays only the contour of a person's head. Interestingly, the syle of this picture very much resembles the way in which people, who want to stay anonymous on television, are filmed (see fig. 4).

[8] Unfortunately there is no standard reference book that neatly summarizes this very heterogeneous, collection of books and papers which include sometimes conflicting views and claims on actor-network approaches. For an annotated bibliography, see Actor Network Resource, compiled by John Law and online available at http://www.lancs.ac.uk/fass/centres/css/ant/antres.htm

Fig. 4 "Anonymous" picture on Wireless Leiden volunteer list[9]

The picture communicates to the rest of the community that this person is clearly not as much involved as other 'members'. The text accompanying the empty picture reads:

> "*User* of Wireless Leiden from 26-12-2003. *Became more active* during 2004, until now *only as NAV* (Node Adoption Volunteer) of the Cetim, or Hooglandse Kerk. In case of problems do not mail or call me personally, but send your e-mail to gebruikers@lijst.wirelessleiden.nl"[10] [Italics by SV]

That this person categorizes himself as a user is in this regard highly significant, because the others on the same list do not use the term 'user'. Perhaps partial invisibility is used here as active strategy out of a practical concern not to be bothered by other WL users in case of malfunctioning hardware.

Back to theory: what is the relevancy of all of this for theory about community innovation? The problem I encounter on a theoretical level is how to deal with employing ant as a theoretical framework in the case of actors that are only partially connected to the network, those who actively resist enrolment while simultaneously reinforcing the network (a point made earlier in research on the relationship between amateur scientists and museums (Meyer 2006)). Clearly the person from the example is not as involved as other 'volunteers', and this is his own wish. How can we conceptualize actors who are involved in the stabilization of community innovations, however are only partially connected by weak ties having no interest in being strongly aligned with the project as a whole and most certainly having no wish to belong to the 'community'?

By choosing the community as the central unit of analysis, those who are no part of the community automatically disappear out of focus. Although recently STS academics have stressed the sensitivity towards those actors that are completely not connected, by conceptualizing them as specific types of non-users, such as resistors, rejecters, excluded or expelled (Bauer 1995, Wyatt 2002, Wyatt, 2003), I myself

[9] Source: http://www.wirelessleiden.nl/stichting/vrijwilligers.shtml
[10] Source: ibid.

find it still difficult to conceptualize the role of those who are somewhere in-between use and non-use. On the one hand these actors are using the community innovation, however simultaneously they are no part of the 'innovation community' and as such non-user of many of the shared tools and communication channels that link its members and shape their sense of shared identity.

The involvement of these in-between-users of community innovation is usually very limited in term of investing time, energy, resources and 'sense of membership or belonging' however cumulatively they often perform a major bulk of the work without the 'core group' of experts (both professional and avocational) would often not be able to create innovations that are actually 'usable' outside the context of original emergence.[11] In this sense, both these actors themselves as well as the work they do often remain 'invisible' (Shapin 1989, Star 1991, Star 1999, Oudshoorn 2006).

To sum up: the interesting empirical finding is that there are many instances of grassroots bottom-up, initiatives out of which a complete 'community innovation system' emerged that 'works' in the sense that they grew into massive undertakings that are able to handle *all phases* of the innovation process from idea to prototype to manufacturing, distribution and service and support. What is especially remarkable is that resources in the form of financial budgets to pay for personnel and tools are usually lacking. The question then becomes how the necessary maintenance work of the technology is organized and arranged by the community itself. This is an especially interesting question, because the 'users as sources of innovation' literature is currently mainly concerned with the free circulation of information, instead of the blood, sweat and tears of the hard work to not only invent and build community innovations, but to keep them working over a prolonged time. The explicit focus on maintenance work can be seen within the tradition that stresses the importance of 'invisible work'. This research strand foregrounds actors originally deemed unimportant (such as secretaries, housewives, nurses, call centre 'reps' or technicians), by further investigating their essential roles in keeping complex systems working (for example see Shapin 1989; Star 1991, Oudshoorn 2006).

Framing maintenance within 'infrastructures of support'

One of the points of this paper is that in order for this exchange of information to take place, an underlying infrastructure is necessary. This infrastructure is not an infrastructure in the purely technical sense, but an 'infrastructure of support' which can best be understood as a socio-technical 'assemblage'. In order to further work out the 'infrastructure of support' I built on the work of Leigh Star on infrastructures, Paul Ceruzzi who introduced the term in the first place.

[11] See Benkler 1999, 2006. Also a number of quantitative survey-studies on open source software development communities have made this point (e.g. Ghosh and Glott 2002, Lakhani and Wolf 2003)

In this section I frame innovations as socio-technical systems that cannot function without maintenance networks. In order to be able to understand how Wireless Leiden organizes its network of maintenance we take a short detour along some theoretical literature helping us better understand the role of maintenance in relation to the emergence of innovations.

Let us refocus on ICT again. A more applicable comparison that can enlighten the relation between ICT innovations and users arranging support is offered by historian of technology Paul Ceruzzi. Ceruzzi (1996) describes the personal computing 'revolution', which in his analysis could only emerge because of convergence between interactive conversation computer systems and increasingly powerful computer chips. However without the emergence of a parallel 'infrastructure of support' next to the technological trends of interactivity and miniaturization these trajectories would not have converged.

> "Here is where the electronics hobbyists, cousins of the pocket calculator aficionados, come in. This community had a long history of technical innovation [...] This group supplied the key component needed to make the transition from the microprocessor to the personal computer; an infrastructure of support that neither the minicomputer companies nor the chip makers could provide. [...] Selling a computer for less than 400$ meant that the extensive support and infrastructure that mini and mainframe companies supplied had to come from elsewhere. For personal computer owners, it came from user's groups [...], informal newsletters, commercial magazines, local clubs, conventions--even retail stores." (Ceruzzi 1996, 17-19).

Although Ceruzzi nowhere mentions the term community innovation, I read his account of the origins of personal computing as a distributed community innovation. The 'infrastructure of support' Ceruzzi describes consists of a 'technical hobby community' (Haring 2007) which would professionalize into a complete 'support industry' in the form of computer clubs, magazines, newsletters and conferences.

By defining an 'infrastructure of support' as something consisting of humans, Ceruzzi seamlessly fits into the tradition that understands infrastructure analytically as "a relational property, not as a thing stripped of use" and as something that is "part of human organization" (Star & Ruhleder 1996, 113). Lindsay (2003) wrote about the phenomenon of users who provide their own infrastructure of support in the case of vintage TRS-80 personal computer users. In her study a user community takes over maintenance and support roles when the original manufacturer Tandy abandoned its own creations. Not only does the community as a whole provide support for other TRS-80 users, they also take over maintenance activities and even provide spare parts and repair services, either by supporting do-it-yourself repair through extensive walk-you-through manuals or by other TRS-80 users offering commercial repairs. Here we can clearly see a community's agency taking over maintenance and support roles traditionally provided by commercial services or the original manufacturers.

Let us focus even more in detail on the relation between commercial commodities and the role of the end-user with regard to maintenance and support

In the case of community innovations in general, and in the Wireless Leiden case in specific, there is no such entity as an ideal typical 'User' involved. What is distinctive for innovation communities is the diversity of the people involved. In a previous paper on Wireless Leiden the focus was on the user-innovators, who can be best described as hobbyists, tinkers or hackers. In this paper the focus is on the 'end-user' of community innovations, or in terms of diffusion theory the 'simple customer' (Latour 1987, 137). In short: people without technical expertise, hobbyist or volunteer motives, or economic interests in relation to a novel artefact. However, we can ask the same question Latour raises: "how simple is a simple customer?"

According to Latour, the 'customer is "'simple' because he or she does not have to redesign" the technological artefact (ibid 137). However the fact that the user has had no role in the original design of an artefact does not mean that there is no active involvement:

> "[E]ven when the phases of development and innovation have ended, the darkest black box still has to be maintained in existence by not so simple customers. […] The more automatic and the blacker the black box is, the more it has to be accompanied by people. In many situations, as we all know all too well, the back box stops pitifully because there is no salesperson, no repairer, no spare part. Every reader who has lived in an underdeveloped country or used a newly developed machine will know how to evaluate the hitherto unknown number of people necessary to make the simplest device work! So in the most favourable cases, even when it is a routine piece of equipment, the black box requires an *active customer* and needs to be accompanied by other people if it is to be maintained in existence."

It is exactly this active customer or active user that we follow in the case of Wireless Leiden. What makes community innovations so interesting is the way in which they differ from 'commercial' innovations that are distributed via the free market to simple customers. The innovation chain is usually depicted as a linear line with at the left side at the start the inventor/innovator who generates the idea, in the middle the producer/manufacturer who transforms the idea into physical mass-produced artefact and at the right side at the end the user/consumer who buys the product. What is important here is that the end-user is a simple customer who is simple as Latour (1987, 137) states "because he or she does not have to redesign" it.

When a device stops working, it needs someone else to solve the problem. This is what we call 'maintenance'. When a user stops working, he or she needs someone else to solve the problem. This is what we usually call 'support'.

When we are dealing with community innovations (networks in which the community and innovation are intertwined as heterogeneous assemblage) this become more complex. How are both maintenance and support organized in community innovations? How is the 'infrastructure of support' for both the WL community as well as the WL Wi-Fi infrastructure organized? The specific focus for this paper is how users themselves organize maintenance of a socio-technical system, when the resources of traditional corporate organizations are lacking such as call centres, service and repair personnel and even budgets are lacking. One of the perceived problems of community innovations is that guaranteed service and support are lacking, making the service or technology in the eyes of the users inherently unreliable. Let us have a look at how WL deals with this issue.

Supporting residential end-users

The history of the innovative Wi-Fi use started in 2001 when one person got the idea of changing 'indoor, short-range, cable-replacement' Wi-Fi consumer devices into 'outdoor, long-range, infrastructure'. Instead of trying to accomplish all the work alone, this user-innovator started to actively recruit people from the local Linux open source software community to help accomplish the goal of building a local free wireless communication infrastructure. In 2002 the initiators came up with a name, goals and an official organization structure for what had by now become a 'project'. In the summer of 2002 both a website and an official foundation were registered under the name 'Wireless Leiden'. From that moment on, an active public relations strategy was pursued trying to get 'in the news' as often as possible. To make the local networking attractive for residential end-users, through the partnership with the Internet Service Provider Demon free access to World Wide Web was offered through the donation of three 8Mbit ADSL connections. What had started as a technical hobby club for Wi-Fi hacking had set its goals to the building of a local wireless infrastructure.

The group of people involved with Wireless Leiden consists of a four different types: First, there is a 'core group' of technical Wi-Fi hobbyists taking care of designing, prototyping, testing, building, and maintaining the local Wi-Fi nodes on the one hand and managing all 'paper work' such as notes of meetings, press releases or financial reports on the other hand. Members of this group are officially enlisted on the WL website as 'volunteers'. Second, there is a growing local user base connecting to the wireless network to obtain free Internet connectivity, to engage in local file sharing. Local companies, schools and libraries use WL as a free replacement for expensive dedicated 'leased-lines' to connect geographically dispersed offices' Ethernets into one single coherent 'virtual' network. Third, there are hobbyists interested in Wi-Fi technology but not living in Leiden, and thus unable to use Wireless Leiden. Fourth, there are external

parties such as the press, local municipality, regulatory agencies or potential sponsors. As 'interface' between the core group of volunteers on the one hand, and the rest on the other hand a non-profit foundation was created in 2002. The WL foundation acts as a 'front-office' for public relations activities as well as a legal person for creating legally valid agreements with other organizations and companies. With regard to supporting the local user base, since 2005, the local municipality offered free accommodation where volunteers can meet, where 'helpdesk' office hours are held, and where the board can meet. The fact that individual Leiden residents, privately own many Wi-Fi nodes, makes the network very special and difficult for regulatory agencies to get a firm grip on.

Although in consumption studies, consuming is seen as an 'active' act, this is certainly true in the case of the use of a community innovation of which WL in this paper serves as an example. In the case of subscribing to a commercial Internet service the path to be taken is clear. For ordering the 'installation package' as a consumer you can choose between different service channels: filling out a website form, talking with a company representative on the phone number or visit a local shop. In the case of community innovations things get complicated: how to 'buy' or 'subscribe' to Wireless Leiden? What are the 'service channels' when there is neither 'store' nor 'web shop' to order your 'installation package'?

Following a WL end-user: the role of warm experts

To give a better insight in the users' perspective of Wireless Leiden, we follow a typical WL end-user, called Linda to see how she managed getting herself and her family connected to the Internet via the Wireless Leiden infrastructure. Linda lives in a small town of approximately 22.000 inhabitants near the city of Leiden. She works at a small law firm as a lawyer, is married and mother of two children of primary school age. How did Linda make the active decision to start using 'Wireless Leiden' and managed to create a working connection?

For Linda the Internet entered her house in the form of a phone line connector at the backside of her computer. Every time she clicked on the Internet Explorer icon on her Windows 98 desktop, the computer automatically connected to the Internet. Because the phone connection in her house was of the 'ISDN' type, her family could surf the web and have phone conversations simultaneously. When in the summer of 2004 she bought a new computer (a special discount offer at the local supermarket) she discovered it was lacking a built-in ISDN connection. In order to restore access to the Internet again she now had several options. Or to frame it differently, Linda was standing at a 'consumption junction' (Cowan 1987): continue with ISDN, or alternatively organize a subscription to cable or ADSL Internet. In the case of ISDN she would have to buy a new ISDN modem. What bothered her however, was the 'pay per minute' subscription

model. Especially now her two children were increasingly using websites such as *Wikipedia* to complete school assignments, she disliked this idea, because this could turn out to be an expensive affair when considering her children's increasing Internet use. The second option then would be a subscription to cable or ADSL Internet, both available in her town. Then the connection fee would consist of a fixed monthly amount.

But then, serendipitously, a local third alternative offered itself when her father during a weekend visit opened his Wi-Fi enabled notebook computer, and noticed a Windows message that told him he was connected to something called 'ap-omni-hofwijck'. This appeared to be part of the Wireless Leiden infrastructure. After some fiddling with the proper configuration of something called a 'proxy' (for some browsing on the web her father temporarily used his commercial GPRS subscription), the notebook computer was able to surf the web. And the best thing: it all worked for free. A few days later, when browsing the web at work, Linda finds that a local Leiden hardware store sells all the necessary equipment to connect to WL. In the weekend Linda and her husband visited the electronic shop and for about 150 euros they had a complete 'package' with outdoor Wi-Fi antenna, 'bridge', indoor Wi-Fi access point. In this way, they did not need to install any additional cabling between the rooftop antenna and their PC located in the living room on the ground floor.

From Linda's perspective WL offered a 'free Internet' without time restrictions. Additionally she sympathized with the fact that the local Leiden initiative was based on the idea of 'free access for all'.

> "Of course I knew it was going to be different, because when you subscribe to an ADSL connection, an installer comes to do all the work for you and then everything works. And Wireless Leiden requires a lot more self-activation. You need to install an antenna on the roof of your house, and then you need to install all the indoor cabling or buy an indoor Wi-Fi router. Actually, it was quite a hassle to get everything working. […] Luckily, when we made a phone call to the shop, the owner was prepared to drop by and fix the whole thing and make it work. He did this for free; I believe it was a kind of goodwill service."

Linda was encouraged to try out the 'free Internet' when she bought the Wi-Fi set, and the shop owner assured her that if the Wi-Fi solution did not work out, she could return the package and get her money back.

However when some time later new problems arose with the WL connection, Linda could not fall back on the shop owner anymore for support. After some browsing of the WL website she decided to send an e-mail to the WL user mailing list. In the subject heading she framed her problem, as "Nitwits want Wi-Fi in the vicinity of Leiden". The first thing that happened was that other people send her a 'debugging checklist'. This is a specially crafted document to guide novice WL users in concrete steps to the procedure of

establishing a working connection or otherwise pinpoint the exact problem in case of failure. In Linda's case this strategy failed, and as a final resort one of the volunteers had to come to visit Linda's house to help her solve her connection problem. Although WL is a volunteer organization, there is no such thing as a free lunch. As a favour in return Linda was asked to give a presentation during a general introduction meeting about WL specially targeted to potentially interested users, which she also did. So here we see a pattern of new end-users who are actively helped getting connected by neighbouring WL volunteers. In return for this support active participation in the form of helping others is expected.

Following a Wi-Fi node: the role of warm users

The preparedness of end-users to actively engage with the technology is of crucial importance for the functioning of the WL community technology. Without maintenance eventually every technology breaks down, however community technologies such as WL depend even more on active maintenance work. The specific problem with community technologies is that the initiating designers of the system often are not interested in the maintenance. This is also true for WL. Most of the technical experts are more interested in experimentation with new technologies that in fixing a wireless node for the hundredth time. When the technical enthusiasts speak about their motivation for participating in WL they often use a frontier metaphor of 'pioneering' or 'cowboy-ing', however caring for the both end-users or technology is missing from this vocabulary.

This lack of motivation for maintenance and support tasks is something many WL participants have observed themselves as a potential problem for the further growth and development of WL. As a solution for the lack of resources for maintenance work a strategy for delegating tasks to end-users emerged. In order to systematically bring end-users into action to the greater good of the WL network, a specific new 'role' within the community was invented: the so-called 'node-adoption-volunteer'. Interestingly enough in this case the term 'adoption' was introduced to describe the relation between the active end-users and 'their' Wi-Fi nodes. Adoption implies a warm implicit undertone of respectfully taking care of a 'child' who from now on will be a member of the family. The adoption metaphor fits in with the locus of the community. The 'adoptee' in need of help in this case is a Wi-Fi node located nearby. The 'parent' is the end-user who relies on the node for its Internet access. The family is not the household, by the wider WL community.

In this section I trace back the emergence of the so-called 'node-adoption-volunteer'. In February 2004 one of the residential end-users of the WL infrastructure decided to add a more positive note to his e-mail complaint about the breakdown of the WL Internet gateway:

> "I feel like the aggrieved consumer who can only complain ... that is not the position I want to take up. I would like to contribute too, but when I look at the list of vacancies I become disheartened by the level of expertise that is required: project leaders, people who know the ins and outs of TCP/IP."

What this user implicitly asks is: I would like to give something back to WL, but I do not know what or how; can somebody help me to contribute to WL? With this post he starts an e-mail discussion in which the 'usefulness' of user-contributions is discussed. After several invitations to join one of the "technical meetings" or the "systems administration mailing list" one of the 'technical experts' ironically further sparks the discussion when he states that "unfortunately it is not attainable that every user can contribute something to the network, except for additional data traffic ;-)". One of the initiators responds:

> "I do not agree with you on this, because I do think anybody can contribute something. You do not need any understanding of computers. For example helping organizing meetings or with the maintenance of the website are important activities. One of the most time consuming jobs is powering nodes on/off. Something not to be done very often, sometimes such a machine happily runs for half a year or even longer. However sometimes it is the only solution to bring it back to life. Perhaps it is an idea to let users adopt the specific node they are connected to, in order to monitor its performance, report problems or if necessary reboot the machine on location. Additionally, a yearly inspection if everything is still well connected. The advantage is that they live close-by and immediately notice problems in case of a malfunctioning. Not difficult to do, no special expertise required and it would save the volunteers a considerable amount of time. And above all, this way even more people are actively engaged with the network."

In the following days several users 'volunteer' to adopt a node, the official term 'Node Adoption Volunteer' emerges, and in April 2004 the first 'node-adoption group' meeting takes place. One person summarizes the 'gift economy' from the end-user's perspective: "I would like to invest some time into this so I can do something in return for the Wireless Leiden network I am using." An 'official volunteer' responded in an agitated manner: "Then put some of your time in other WL projects. That way you show that it is not directly self-interest!" Another official WL volunteer puts this remark in perspective by noting that "we should also realize that self-interest is not too bad, because in the end the network is served by it as well: or in modern management-lingo a win-win situation". Another poster agrees as well: "Of course there is self-interest: learning new things and spending your free time useful, but that is true for all WL volunteers". In November 2004 and January 2005 the WL end-user who signalled he would like to contribute but did not know how, gave a presentation during official meetings about 'the user annex node-adoption-volunteer: his

presentation is announced as “a WL user talks about his experiences as user and node adoption volunteer of one the most important nodes of the network”.

Informal support infrastructures of warm users

Informal support is not something that is confined to community innovations. In her research on the domestication of the Internet, Bakardjieva (2005) noticed a similar phenomenon.[12] The fact that Bakardjieva explicitly focused on domestication of Internet access allows for a comparison of her empirical material with the WL study.

Bakardjieva (2005, 98) noticed that the ‘domestication’ of the Internet “had been intensively assisted by a close friend”. She called this person the ‘warm expert’, which she defined as:

> “The warm expert is an Internet/computer technology expert in the professional sense or simply in a relative sense compared with the less knowledgeable other. The two characteristic features of the warm expert are that he or she possesses knowledge and skills gained in the system world of technology and can operate in this world but, at the same, is immediately accessible in the user’s lifeworld as a fellow-man/woman. The warm expert mediates between the technological universal and the concrete situation, needs and background of the novice user with whom he is in a close personal relationship.” (Bakardjieva 2005, 99).

The ‘economy’ of the warm expert helping out a close-by person is not a financial one such as the relation between repairmen and customer, but gift-based. In return for helping out, the warm expert is offered for instance “lunch and, as one can imagine, the enjoyment of spending time with a friend.” (ibid., 101). In WL we see the same mechanism at work, although the dimension of proximity is organized within the WL community. In WL we see a ‘gift economy’ in action, and ‘reciprocity’ towards community members (‘tit-for-tat’) is how the keeping-it-all-working is organized. When an expert helps a user to get connected, the user then is asked to help other users by rewriting ‘debugging check lists’, by giving a presentation in for end-users comprehendible language or by taking over relatively easy ‘maintenance’ tasks. In this way the end-user also helps the expert with maintenance of the technology and support to the (end-user) community.

A difference emerges between getting connected to the Internet via a commercial ISP or via a community innovation such as WL. In her introduction Bakardjieva writes that:

> “Users are hard to perceive as a social group that shares a common technological frame because of their dispersed state of existence, as well as their diverse cognitive and material resources, interests and ideologies. Users inhabit numerous invisible everyday settings. They have no

[12] The idea of the ‘warm expert’ was first articulated in Bakardjieva and Smith (2001). Stewart (2002, 2007) introduced the related concept of the ‘local expert’.

> established forums or channels for interaction either with each other or with the designers of the technologies they employ. In contrast, researchers, engineers, managers and government representatives form distinct professional networks. They share cognitive frames of reference acquired in the course of their training and subsequent participation in a community of practice." (ibid., 13)

In the case of community innovation the relevant difference is the availability of 'forums' and 'channels' in the form of local meetings, mailing lists and interactive wikis. It is actually through these channels that interaction with the designers of the system is possible, through the aforementioned 'channels' or 'nexus'. This then results in the formation of a 'community of practice' organized around the shared participation of in this case WL. For 'warm experts' to be able to function in the case of community innovation in which people are often no friends or relatives (yet), there is an infrastructure needed through which people can ask for 'help'. This infrastructure then is an 'infrastructure of support' that enables the correct functioning of the users and the devices interacting with each other.

Within a community innovation the gift economy is one of the principles on which maintenance and support work is organized. Examples of reciprocal gifting by end-users in return for help are writing documentation, answering e-mails of other novice users, and giving presentations. Warmth then also refers to the gift economy instead of a financial economy. Where in the traditional situation you would pay money to the company that pays the salary of the repairmen, in the case of community innovation, you 'pay' the community of which the warm expert is a member, by donating resources back to it in the form of time, energy or concrete products such as manuals, documents, bug reports, or answers to questions.

In this sense not only the warm expert who with his[13] intimate knowledge of the inner workings of the technology can help the user, but also the warm user[14] with his intimate knowledge of how he or she thinks new technologies work can help the experts with supporting the community, but also with literally and figuratively holding the technological devices in order to get connected again to the network in case of a problem. The unit of analysis then is not the individual user, but the community innovation as a whole, consisting of both humans as well as non-humans. If elements of the network, for one reason or another, get disconnected, warm users can then help these to get connected again. In the situation of a commercial Internet access subscription unstable technologies are not accepted, and the company is expected to fix problems as soon as possible. However, in the case of community innovations, end-users are more forgiving and prepared to 'help' the technology in case of a failure.

Where Bakardjieva (2005, 102) writes that "[t]he learning experiences of new domestic users of the Internet recounted here thus exhibit a profoundly social character" I argue that in the case of WL this social

[13] Iets zeggen over gender aspect van warm expert, often male gendered.
[14] SV-Todo: this concept needs a better introduction...

learning is organized technically through wikis, mailing lists, homebrew 'debugging lists' and organized socially through local meetings and personal visits. In addition when Bakardjieva (ibid) writes:

> "Friends and relatives, and to some degree online helpers, had taught my respondents not only how to navigate the interface but also what they themselves had discovered the Internet could do for them as a communication medium".

In the WL comparison however end-users have learned not only what WL can do for them, but also what they can do for WL. Vis-à-vis a perspective of 'warm expertise' a perspective of 'warm use' has emerged. Where support of end-users is organized by warm experts helping people to get connected, the equivalent is maintenance of the technology organized by warm users helping devices to get connected again if needed. The underlying goal in both situations is to reconnect elements that got disconnected from the network. In the case of community innovation, the warmth based on proximity and personal physical contact not only applies to humans but also to non-humans.[15]

"Engagement capacity" as an alternative translation mechanism

The interesting thing is that in community innovations tasks that are normally delegated to the technology, in order to keep maintenance by human people to a minimum because technology is less expansive than human labor, are delegated back to the humans again. This can be understood by the different requirements for community innovation is which budgets for expensive reliable hardware are lacking, however simultaneously free labor by volunteers is often available in large quantities. In this sense the 'engagement capacity' (Verbeek 2000) of the homebuilt Wi-Fi devices is very low (the only interaction required by the maintainer is checking the status of the LED lights and pressing the power switch). However, the 'engagement capacity' of the node adoption volunteer is quite high, willing to conquer bad weather to perform simple maintenance tasks.

But what is it that causes this high 'engagement' of end-users to be willfully enrolled as volunteer, or more bluntly stated unpaid, maintenance personnel? In terms of actor-network theory: how are end-users enrolled as reliable actors into the network, and how are their interests translated into those of WL; and by what mechanism? Certainly, there is no mechanism of force at work here: users have plenty alternatives to obtain hassle free cheap Internet. Additionally they do not receive any wage that can motivate them to perform their maintenance work as stated in their job contract. Solving challenging puzzles, obtaining new skills or gaining increased reputation amongst peer possibly leading to increased career opportunities are also not at play. I would like to propose a fourth translation mechanism, one that is based on 'caring'.

[15] SV-Todo: comparison with the following works seems suitable: Verbeek 2000, Bijsterveld 2004 or Latour 1992

Actors enroll themselves because they are intrinsically motivated to do so, attracted by the fact that they simple have developed 'warm' feelings towards the overarching ideal, goals, values or motives on which the community innovation is based. In this sense just as people care for other people, not simply because they must do so, but because they feel that friendship relationships should be based on reciprocity, a similar argument is followed when these 'node adoption volunteers' explain their motivation for their actions.

In this sense the 'engagement capacity' in the form of 'attachment to technology' is based on the degree of 'warmth' an actor develops towards the community innovation as a whole. Can he or she identify with it in a positive manner? Does it make them feel 'good' to be involved actively in this initiative? Although these users feel they cannot contribute back to the community innovation by lack of technical expertise and interest that is often required to become a member of 'technical hobby communities' they are nonetheless willing to invest some of their time in other tasks.[16]

Conclusions: warm users and the stabilization of community innovations

The idea of attachment to technology is not new. For example Verbeek (2000) already introduced the notion of engaging technologies. Also the link between technologies with a high 'engagement capacity' and higher involvement of users in maintenance and taking care of the artifact is not new (also Verbeek). According to Verbeek designing an artefact in such a way that a high 'engagement capacity' is built into the artefact, it can be used in a more sustainable way through the stronger relationship with the user, who then is much less inclined to throw the artefact away in case of damage, malfunction or just not being fashionable enough anymore.

However, in this paper we have seen the engagement coming from the side of the user. The artifacts from the prelude are not that engaging at all: they only require the simple act of pushing a button to reset, and that is it all there is to it.

Two conclusions emerge from rereading literature on user communities that are highly involved into supporting specific technologies. In the first place the importance of the availability of infrastructures of support, whether locally in the form of meetings, or trans-locally organized through mailing lists, wikis and websites. Secondly, the importance of attachment to the technology based on 'care'. Rereading case-studies from the literature from the perspective of the 'warm user' lead to the question if this phenomenon is only limited to community innovation, but perhaps also extends to commercial innovations as well?

[16] An explanation that aligns with this analysis is the phenomenon known in psychology as the 'helpers-high'. People who help others, feel better themselves afterwards. Luks (1988, 39) states that "People who exercise vigorously often describe feeling high during a workout, and a sense of calmness and freedom from stress afterward. New evidence reveals that these same emotional and physical changes can be produced by volunteering to help others." The analysis of Luks thus enables us to rethink the 'materiality of altruism' in which endorphines in the human brain are involved in making people 'give something back' in order to feel better themselves.

Another domain where warm users take on them the role of 'maintaining and caring for technologies is in the case of 'orphaned technologies', no longer actively supported by its original manufacturers. Lindsay (2003) describes a compelling story of how TRS-80 computer users themselves have taken over the care for these computers, thus providing them with a 'new lease of life' (ibid, 50). However, where Lindsay focus mainly on TRS-80 users constructing an identity based on technical expertise, and on nostalgia, I would reframe these users attachment from the perspective of care, or as one user said: "We loved them." (ibid, p. 46). A similar reinterpration is possible with the case-study by Muniz and Schau (2005) who describe how the 'abandoned Apple Newton' community that literally keeps these vintage devices alive. Although they explain the attachment of the Newton users as a sort religious, devotive relationship, I would reframe their analysis again as a form of care by users for their technologies. Interestingly enough the authors draw parallels with fan communities of TV-series. However as the sources of community between these users I would not foreground religiosity but simply the warm feelings for the technology itself. My third example is in the domain of small-scale sustainable energy. Ornetzeder and Rohracher (2006) describe how with the help of users, sustainable energy innovations such as thermal solar collectors, biomass heating systems and sustainable buildings were introduced succesfully in Austria. Although the authors state that "[a] specific and high motivation of users is needed to invest sufficient amounts of time and energy" (ibid, 147) these motivations are linked to issues such as 'cost reductions', 'environmental reduction', 'regional development', 'energy saving' or 'using ecological and healthy materials'. However, all of these can be seen as specific reasons for the same underlying phenomenon, namely why users 'care' about these new technologies and are committed to invest time and energy into the attachment of these technologies into their everyday life. So not only novel technologies that are still fragile because they have some 'children diseases' but also 'senile' technologies that suffer from their age are cared for by their warm users.

Earlier studies of science and technology pointed us to the importance of 'invisible' actors in the practice of 'doing science'. Shapin (1989), for instance, pointed to the importance of the generally overlooked 'invisible technician' in the history of science, without whom we cannot understand science as a practice. Following this line of thought in the field of innovation studies, my argument is twofold. First, community innovation as a process cannot function without a certain degree of user diversity. Second, community innovation is based on both technical expertise as well as affective attachment to technology.

With this paper I hope to have sensitized the reader to the importance of the 'warm user' in the practice of maintaining community innovations. By doing so, I hope to have changed the image of a consumer of new technologies as a 'simple customer' into an 'active user'. The difference between a user-innovator and a warm user then is that the user-innovator actually works 'under the hood' of the technological black box, while the work of warm users can better be understood as articulation work that remains invisible to

outsiders of the community.[17] The phenomenon of active end-users as an essential part of the 'infrastructure of support' of a distributed innovation are not only limited to grassroots/bottom-up/non-profit/non-commercial ICT network innovations. In the case of Wi-Fi networking interesting models are emerging in many different shapes and sizes in various locations. A very interesting example is the FON initiative (www.fon.com), in which a company tries to mobilize residential Wi-Fi users to share their commercial ADSL or Cable Internet access with a global 'community' of 'Foneros'. Users themselves pay for the local Internet connectivity, for the Wi-Fi hardware, the electricity bill and the maintenance of this configuration. Motivation of participation is organized along the line of becoming a 'Fonero', a member of the 'FON community'. Eventually the company hopes to introduce a financial compensation model for the 'Foneros' as well; at this moment it has not yet realized however.

An interesting question concerns how far users will be motivated by and are able to identify with commercially organized distributed network innovations in which they are supposed to play an active role. This will depend on finding strategies to mobilize users' sympathy in order to access their resources. In this respect further research is needed to develop a better insight into the enabling and constraining elements that configure the appropriation and domestication dynamics of distributed ICT innovations in which users play a crucial role.

Typically end-users are conceptualized by designers as passive entities, not interested in how the technology works 'on the inside'. Users are supposed to be stupid and have to be protected from their own behaviour by designing technology that is 'foolproof'. By 'giving voice' to the invisible work of warm users, I hope to contribute to replacing the common conception of the end user as a 'simple' customer with a more active image of a user who cares, is based on empirical study of use practices instead.

[17] SV-Todo: insert references to recent paper Oudshoorn, and other literature

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