Artful Infrastructuring in Two Cases of Community PD

Helena Karasti and Anna-Liisa Syrjänen
Department of Information Processing Science, University of Oulu
PO Box 3000, FIN-90014 University of Oulu, Finland
+358-8-553 1900
{helena.karasti, anna-liisa.syrjanen}@oulu.fi

ABSTRACT
In this paper, we use the notions of artful integrations and infrastructure to analyze two cases of community Participatory Design 'in the wild'. Though the communities are quite different on the outside, they bear surprising similarities when it comes to collaboration in technology design. We identify several features of how the community members artfully integrate their everyday materials, tools, methods and practices into collaborative processes of infrastructuring. The notions of 'artful integrations' and 'infrastructure' sensitize our analysis towards a more conceptual understanding on information system development as multi-relational: socio-material, socio-historical and processual. We conclude by suggesting some refinements to the notions in the context of community PD.

Categories and Subject Descriptors
H.1.2 [**User/Machine Systems**]: Human information processing; J.3 [**Life and Medical Sciences**]: Biology and genetics; K.4.3 [**Organizational Impacts**]: Computer-supported collaborative work; K.6.1 [**Project and People Management**]: Systems analysis and design, Systems development

General Terms
Design.

Keywords
Participatory design, community design, infrastructure, artful integrations, information management, dog breeding, ecology.

1. INTRODUCTION
This paper explores Participatory Design in two communities as a form of 'artful infrastructuring'. By bringing together the study of technology development as artful integrations [22] and the notion of infrastructure [20, 21] it builds towards a more sensitive understanding of community PD as embedded, ongoing, and multi-relational activity.

We are interested in studying the existing varieties of community information technology development by non-professional designers 'in the wild' (see also [1, 4, 5, 6, 7, 25]). We believe there is a lot to be learned from their insights, practices and methods for the traditions of Participatory Design and recognize the importance to broaden existing understandings of the social and organizational contexts of where PD actually takes place. Both communities can, very concretely and in several ways, be characterized as 'PD in the wild'. They exist out in the 'real world' and their members as layperson-designers carry out and take responsibility over technology design. Furthermore, their information technology development is thoroughly and complexly embedded and interwoven in the communities' activities with nature.

The two case studies represent very different kinds of organizations: Long Term Ecological Research (LTER) is a scientific research network in the United States, whereas the Karelian Bear Dog community (KBDC) is a way of life group of special interest enthusiasts in Finland. Within these organizations of some thousands of participants, we have focused on two technology design groups of some dozens of members that form Communities of Practice [14]. The CoPs have evolved over time as the members have started to use, experiment with and design technologies alongside the ongoing development of the main activities: information management for ecological research and dog breeding. The CoPs are particularly important as informal forums for interaction, sharing, learning and collaboration on the specialty areas of members' interests, which may be only a subset of the entire organizations' pursuit. Through relationships based on respect and trust, the members have developed a common sense of purpose and a desire to share technology-related knowledge and experiences, which contribute to reciprocity, joint materials and methods and shared strategies for developing technologies.

In comparison to virtual and web-based (PD) communities, that are born as new possibilities in technological mediation emerge (e.g. [16, 18]), our case communities exist irrespective of certain kinds of digital technologies. Their purpose, identity, membership, main activities, norms and regulation, and defining episodes have lived (though maybe not unchanged) through several transitions of technologies. Yet, the communities have also integrated technologies and participatory design into their collaborative activities. In their use and design practices, different media, materials and technologies are accounted for and formed into 'artful integrations' [22]. Interestingly, the communities demonstrate many similarities when it comes to collaboration in technology development. For instance, they employ decentralized, grass-roots processes, and their approach consists of a blurring of the boundaries of use and design, with a gradual development of technology closely intertwined with the development of their main activities.

There is a need for new kinds of conceptual frameworks and theoretical perspectives that allow us to appreciate, analyze, and theorize about the variety of situated approaches of 'PD in the wild'.

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We focus our work upon the notions of artful integrations by Suchman [22] and infrastructure by Star & Ruhleder [21]. They give us a framework for the analysis of technology development as complexly relational, socio-material and historical. While Neumann & Star [15] have considered whether the principles of participatory design can be applied in large infrastructure projects, we come from another direction and address whether the notion of infrastructure can be successfully used to understand community PD. Our aim is to explore, bound and refine the notions in the context of community PD.

After introducing the notions of artful integrations and infrastructure (chapter 2) and using them as a framework to describe the two cases (chapter 3), the paper identifies and discusses – illustrated by empirical data – aspects of artful infrastructuring that are particularly characteristic of community PD (chapter 4). The paper concludes by suggesting refinements to the notions of artful integrations and infrastructure in the context of community PD.

2. THE NOTIONS OF ARTFUL INTEGRATIONS AND INFRASTRUCTURE

The notion of artful integrations has been put forward by Suchman in laying the groundwork for a 'located accountability' approach to technology design informed by feminist theorizing and an awareness of the working relations of technology production and design [22]. She has explored the recent feminist reconstructions of objectivity and suggests a shift from a view of objective knowledge as a single, asituated, master perspective, to one of multiple, located, partial perspectives, and from claims of objectivity in the closure of controversy to one of objectivity through ongoing processes of debate. Based on an assumption that the design of technical systems is a process of inscribing knowledge and activities into new material forms, these arguments apply for technology design as well.

At the heart of artful integrations are the socio-material relations of multiple, heterogeneous elements and the collective, situated interweaving of people, artifacts and processes that make up the working relations needed for, and sustain the visible and invisible work required in, the design and use of technical systems. So, instead of a vision of a single technology that subsumes all others, there is an assumption of the continued existence of hybrid systems composed of heterogeneous media, material and practices; not hegemonies, but artful integrations. From this standpoint, change is an aspect of everyday practice, not the privilege of professional design. The statement of continuity challenges 'radical' technological change and asserts that new forms emerge through juxtapositions and connections of existing forms. If technologies are to be made useful, practitioners must effectively take up the work of design, i.e. appropriating the technology so as to incorporate it into an existing material environment and set of practices [22].

The concept of infrastructure is customarily used in the context of large, material structures, such as networks of roads and electric power, and with technical configurations of wires and pipes. However, this term can be connected also with more immaterial elements and abstract artifacts, for instance, information, its processing with tools, and social arrangements. Star & Ruhleder ground the notion of infrastructure in the tradition of science and technology studies and characterize it as a profoundly relational concept [21]. The socio-technical relation is particularly essential: technological infrastructures should always be seen in relation to organized human practices, as parts of social systems. The definition is profoundly based on a perspective where infrastructures are perceived as performative, that is, they partially create the world they subtend [3]. Infrastructures are seen as historical and processual, i.e. extending over possibly extensive temporal frames and being formed in relation to various ongoing and interrelated processes. An infrastructure occurs when 'the paradox of demassification' is resolved [21], i.e. when local practices are aided by such technology that links them into an integrated system functioning both in large scale and in situ. Hence, seemingly large scale infrastructures cannot exist without small scale local settings (cf. relations of local – global, situated – generic, flexible – standard) [3]. Star & Ruhleder have characterized the salient features of infrastructure [21]:

> the embeddedness of infrastructures in other social and technological structures;
>
> the transparency in invisibly supporting tasks;
>
> both the spatial and temporal reach or scope;
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> the taken-for-grantedness of artifacts and organizational arrangements as learned as a part of membership;
>
> infrastructures shape and are shaped by the conventions of practice;
>
> infrastructures are plugged into other infrastructures and tools in a standardized fashion, though they are also modified by scope and conflicting (local) conventions;
>
> infrastructures do not grow *de novo*, they wrestle with the inertia of the installed base and inherit strengths and limitations from that base;
>
> the normally invisible infrastructures become visible upon breakdown.

At the center of infrastructuring is the integration of new tools and technologies with existing people, materials and tools. Processes of integration, the negotiations and compromises that require technological, cognitive and social resources, are both available and transparent to communities of practitioners. Star and Bowker have put forward the verb "to infrastructure", emphasizing the tentative, flexible and open character of the activity [20].

We bring the above two notions together into 'artful infrastructuring' to sensitize us in analyzing, identifying and describing the socio-material and socio-historical relations, and the processual aspects of participatory design in our two cases.

3. TWO CASES OF COMMUNITY PD

This chapter describes the Long Term Ecological Research (LTER) network and the Karelian Bear Dog community (KBDC), particularly their formation, main areas of interest and activities, and approaches and practices for technology design. Ethnographic fieldwork, with particular interest toward mundane, even 'boring' or 'singularly unexciting' things [19], as well as a view of knowledge and technologies as socially constructed within ongoing communities of practice [2], has been carried out in both communities (for more detailed descriptions of each case see [12, 24]). Syrjänen has also been a long-time member of the dog community. Analyses of the rich corpuses of data gathered, mainly through participant observation, interviews and document/material collection, began individually. Collaborative sessions of qualitative data analysis provided a forum for starting to talk about and compare the cases which led to deeper discussions, interleaved by more focused analyses, and the identification of commonalities between the communities' design practices. The quotes for this paper are mainly from the interviews, though participant observation and document analyses are also heavily drawn on. Excerpts from LTER information managers' interviews are marked with an acronym 'IM'. Quotes identified by a 'DP' stand for interviewed dog persons and/or their historical material in KBDC.

3.1. Long Term Ecological Research Network

LTER is a research network in long-term ecology (http://lternet.edu). The US based program was initiated in 1980 by the National Science Foundation, and has since grown from the initial six, to twenty-four research sites and a network office; in addition there is a growing international LTER network. The US network currently involves more than 1200 scientists and students from a diversity of disciplines conducting multidisciplinary investigations of ecological phenomena and a range of topics in a variety of biomes at the sites' geographical study areas over extended periods of time. Thus, the temporal and spatial scope of LTER, its activities and infrastructures are extended. Furthermore, as cross-site and synthetic work in science have become increasingly encouraged, the manifold interconnections and interdependencies have become more pronounced. [12]

From the outset, LTER placed an emphasis on preserving data for the long-term. Data stewardship is motivated by an awareness of an ongoing loss in informational content and the usefulness of data over the long-term. Though information management (IM) is clearly secondary to ecology, it is an important and required part of each site's science plan. The fact that information managers are located at sites helps to guarantee that they intimately know and can appreciate the local ways and practices of doing science.

Early on, the information managers initiated annual meetings with a representative from each site, which has evolved to a Community of Practice [14]. This provides a collective forum for a heterogeneous group with backgrounds rather in ecological or other sciences than technology or engineering fields to come together for cross-site conversations, joint learning and collaborations in technology development: "it's all like being mentored really by the overall group. So I see we are training folks." (IM)

Though the group has become more established and organized during its existence of over two decades, e.g. it has changed its name from the 'data' to 'information' management committee and an elected executive committee has been formed to maintain communication between annual meetings, it remains an informal and friendly environment "where people can let their hair down, be themselves, be natural" (an IM). It is an important arena for the information managers, who often are alone at their sites, for the sharing of ideas and learning from each other's experiences: "professionally the highlight of the year … in these meetings I find somebody that understands my problems … I find the support that I need". Through annual meetings, on-need workshops, newsletters, listservs and emails, the group defines its community:

> "We have made a greater impact as a group. The network is not so cohesive as far as science goes, every site is very independent … it is the information managers that have really created a network framework. We are an incredible asset to the whole LTER program".

LTER information technologies have been developed around long-term data archival and reuse, more recently data dissemination prompted by a mandate to have all data publicly available two years after collection. Major technologies are environmental data, metadata, datasets and databases, and the Internet. In two decades LTER has been through several generations of technologies: "technology keep changing, original tape library and mainframe system … it is a constant battle to keep up with things" (an IM). Although staying technologically current is a major driver, it needs to be carefully balanced against present investment in technology: "it is not so bad yet that I would want to go and rewrite all my interfaces" (an IM). Information managers' foremost concerns in aligning developing technologies with existing technologies and practices are to minimize disturbance for long-term data management, secure high reliability and ensure easy maintainability [12]. There is an obvious tension between the 'slow time of data care' and fast pace of technology development; the different speeds of different trajectories need to be brought together (cf. [15]). Therefore, long range planning is required to optimize (timing) for major upgrades in technological infrastructure: "we are transitioning our whole design, we are really facing a lot ... then it stabilizes again. Every so often things need to migrate" (an IM). As any piece of technology is ultimately evaluated against its value for ecological research, the ongoing and judicious technology processes produce "a kind of archaeological layering of artifacts acquired, in bits and pieces, over time" [23] that is embedded into and inside other technologies, institutional structures, social arrangements and practices at local sites of scientific work.

Information managers are accustomed to designing technologies in collaboration with ecologists at their sites: "The many facets of technical issues are revealed in the dialogues carried on between information managers and scientists." (an IM) Individual research sites have their own technologies, and vary in their technology development strategies. For instance, some sites prefer to "keep it simple", some promote "data availability and accessibility together with possibilities for exploration", and yet others go after "automating systems and experimenting with new technologies". Coming together in technology design at the network level, information managers are faced with the diversity of sites' approaches:

> "A lot of the bottom-up characteristics are important for LTER information management … ability to deal with heterogeneity not by limiting it but by dealing with it… recognition that there are legitimate reasons for some differences between site systems" (an IM).

Technological heterogeneity is not only allowed, it is also seen as one of the strengths of the LTER IM network. It has, in fact, together with adaptation to the federated way of operating and the long-term way of thinking, contributed to the ways in which information managers collaborate in design through network wide selection processes, where each site is a 'laboratory' with its local specifications.

The LTER IM tradition of 'prototyping into consensus' is based on the idea of each module effort, e.g. a queriable all-site climate database or the conceptual design of a Network Information System, being led by an interested information manager who coordinates design, presentation, and communications with the LTER community throughout development and implementation. Interested sites are frequently recruited to serve as test users and ultimately code designers, as the module becomes a *boundary object* that is shared and discussed, redesigned and modified. Although only a few sites may participate originally, discussions during presentations or break out groups at meetings elicit the voices of the larger community. Another way for collaboration-in-design is described as a 'cherry picking octopus':

> "One of the advantages with 24 sites is that there is always someone doing a major upgrading, they're out there looking for the solution that would work the best, they might find the solution through IM meetings, word of mouth, Databits, and it may also solve my problem (Boom!) … looking around what is going on within the network: 'do not spend so much time looking at your own stuff, that you never look at other's stuff'. I learn more by looking at other LTER sites, if I see they are doing something neat, I'll try to find out how they did it. Good things, bad things. …. There is always some site looking for something new, cherries are the good pieces of software ... 24 opportunities to find good ways, it needs to be an octopus as they need to be connected." (an IM)

On the other hand, collaboration in design is an ongoing common struggle with diversity and consensus, balancing between the local sites and the network as a whole. The LTER IM group has developed guidelines and consent approaches that typically outline a minimum set of requirements that have been jointly developed over time and engender flexibility and openness to accommodate the variety of sites:

> "In IM meetings we brainstormed some basic principles for IM policies … we did not come up with the LTER wide information policy, we would have ended up in endless discussions. We published guidelines for individual site information management."

Recently, the adoption of the concept of the ecological metadata language (EML) standard has intensified the challenges of diversity/flexibility vs. standardization/generic in the design and implementation of EML [cf. 3].

3.2. The Karelian Bear Dog Community

Karelian Bear Dogs (KBDs) have been named after the area in northern Europe, Karelia, the isolation and remoteness of which ensured that the breed remained relatively untouched until the 20th century. The breed dates back at least to the time of the Vikings. Its early associations have been with hunting peoples whose primitive and arduous living-conditions have affected the qualities of the dog. Karelia is a region of forests and streams where "game was plentiful" (a DP) and for centuries the KBDs were part of families both as guards and hunters for bear, elk, deer, lynx and small game. The breed was officially recognized by the Finnish Kennel Club in 1936, and the goal of "creating a sturdy dog that barks at big game" was set. However, difficulties were soon met as the breed nearly got destroyed by a war, and another war ended with the loss of a part of Karelia to the Soviet Union, cutting off access to the vital breeding stock.

The Karelian bear dog community (KBDC), affiliated with the Finnish Spitz Club (FSC, the breed organization of the Finnish Spitz, the Nordic Spitz and KBD), has been founded to keep up the indigenous breed of dogs and to preserve one traditional way of living in Finland. The KBDs' significance is expressed by an ancient poem: "It fed the family, gave drink to the tribe, supported the forefathers". Today most dogs are an essential part of their owners' families and free-time activities, such as dog shows and hunting trials, where the actual hunting event is only imitated, enabling the dog to tests its skills in nature.

The community has over two thousand mainly Finnish members from a variety of educational and social backgrounds. Voluntarism is the basic principle of participation in all community activities, including technology design. The unpaid development work has been carried out for decades by the FSC's dog enthusiasts for the sake of the dogs and the dog people: "nothing has been done for the sake of IT or only on its terms" (a DP). Dog persons' practical understanding of dog breeding has continuously influenced the design and maintenance of the breeding database that is used in breeding dogs for big game hunting and as competitors in hunting trials. Their devotion to the dogs with their potentiality and flexibility as self-learned user-designers has been harnessed in order to transform the available social, material, and technical resources into infrastructure solutions suitable for the community's conditions (cf. [17]).

The 'core activity' of community members' participative practices (ibid), remains dog breeding. It forms the primary shared object of interest for members and the reason for technology design, whereas, for instance, "information technologies are just tools, and more important is the philosophy for which they are used" (a DP). In view of this, the roles of community members as users and developers of information technology appear secondary in comparison to their roles as actors and experts in dog breeding.

For decades the dogs were bred using the then accepted and most general method of dog breeding, i.e., line inbreeding based on the idea that the "best results can be achieved when the dogs are relatives" (the FSC anniversary book in 1987). Inbreeding as such has been disputed in dog communities through the ages, for instance, in an article first published in the 1960s, and then again in the 1980s. In the FSC club magazine it was called "the most disputed breeding method since the era of Aristotle" (a DP). But, due to a lack of proof with real dogs, the dispute has settled down, and despite the associated health risks, many breeders trust line inbreeding, as it has not been seen to cause evident harm to dogs.

At that time the Finnish Spitz Club and the Finnish Kennel Club (FKC) provided the data of members, hunting trials and dog shows that were used for breeding activities. The manual record system provided data in such varied forms and formats that they were difficult to use for breeding counsel and extensive analyses on, for instance, genetic defects and diseases, were impossible to conduct. As a result, a large part of the data corpus remained untapped and a quality analyses of the community's breeding practices could not be made. After fifty years of breeding attempts, "top breeding dogs were still scarce" (a DP) because all potential breeding dogs could not be identified from the mass.

In the end of the 1980's, FSC adopted a participatory, member-driven approach to information system development, and a new database developed by user-designers was introduced for KBDs' breeding in 1990. Later, the system has been further developed by adding new functions and utility programs as needed. For instance, development of a program to calculate a coefficient of inbreeding (CoI) set up a participatory design process with dog-experts sharing a common interest. The chained, multi-phased design process was motivated by articles on inbreeding written by a FSC member with whom another member collaborated. He in turn turned for advice to a third one, and so on, until the formula of CoI had been implemented: "I still have a file of letters we sent to each other" and "nobody has done these things alone, co-operation has always been required" (a DP). The development of the tool that calculates a number of duplicated gene pairs in a dog's genome (a high CoI showing a close degree of kinship and a low CoI more remote dog lines) took over a year. There were problems with existing technologies, computer standards, and with the calculating theory of CoI, which was originally designed for more powerful computers. These and many other issues had to be solved for less powerful computers used by community members in the field. Finally, the application named "Breed" was implemented, presented to other dog persons involved in IT use and design practices and then integrated with the existing FSC's database system (cf. [20]).

The introduction of the new tool into the KBD breeders' local practices turned out to be a 'wicked nut to crack.' One member responsible for advising breeders told: "the most skeptical ones did not even believe that the Breed could be useful for bear dogs" as breeders relied on the line inbreeding method. The slow transition in breeding practices was initiated by a thorough analysis of dogs' CoIs and hunting trial results, which resulted in the epoch-making observation: dogs with a high CoI were less successful in hunting trials than those with a lower CoI. The proofs with real dogs were presented at FSC meetings, repeated in one-to-one counseling events and published in the club magazines. This gradually gained ground upon the too tight inbreeding approach, and reopened the health risk question. From then on, the community has given up inbreeding, step by step, and information systems have been incrementally developed alongside the more extensive change process in the dogs and breeding practices. Even today, the 'Breed' is in daily use and its influence on the KBDs has been significant. For instance, the community has been able to translate their new understanding into the highest numeric value of acceptable degree of inbreeding for new dogs. The CoI limit has become included as a working standard in breeding counseling and in the KBD breeding program accepted by the FSC general meeting.

The current information system, which is a kind of decision-support system, is trusted among members capable of supporting KBD breeding towards the community's goal [24]. The transition of technology from individually held files to an integration of old and new technologies with shared archives and web tools has brought the system to become available to all members. It incorporates several social and technological structures in such a way that the system can account for both the entire community within the field of dog breeding, and also be locally adaptable for each breeder. Through this dynamic reach from global to local practices, including the temporal scope, from history (an analysis base) to future (designed in new pairs of dogs), it embodies the performative nature of infrastructures [3].

The non-professional collaborative design process through which participants contribute to the design work was described by one user-designer: "we just began to work and know-how unfolded as we carried on … we did what was needed in practice … without models … by taking … the trial and show forms as such". Design drew on the common language (cf. [15]) exemplified above in the use of the existing forms and terms. The system was built on the 'installed base' by being embedded in existing social structures, such as the language and forms used in dog breeding practices. Such activity cannot be seen through exact principles, rather it is a dynamic process guided by the task at hand that evolves over time. Usually some amount of 'doing together' (a DP) is needed to communicate skill-related knowledge: "It is the social network … with the aid of which I have done my part of the work" (a DP). It is required for the sake of supporting the heterogeneous sorts of expertise needed to craft and sustain knowledge for the emergent complexities of dog breeding (cf. [8]), and to preserve the revived diversity with several qualities of hunting dogs.

4. ARTFUL INFRASTRUCTURING IN COMMUNITY PD

This chapter describes, as aspects of 'artful infrastructuring', the socio-material aspects of artful integrations, and the processual and socio-historical features of infrastructure that are particularly pertinent to the KBD and LTER communities.

4.1. Raison d'être and Continuity

The two communities are heterogeneous when it comes to their members' backgrounds, but united in community identity through the common causes and members' shared interests. The raison d'être for LTER information managers is to provide support for ecological research over the long-term:

> "You [IM] have to be willing to some extent to accept a support role to the main scientific function of the LTER" (an IM)

> "You [IM] need to keep coming back to the primary reason that you are doing this information management … to increase the research productivity … so that influences your priorities all the time" (an IM).

The purpose for KBDC, in turn, is to preserve and foster the particular aboriginal dog breed without mixing it with other breeds, in the words of one member: "In my work, I have aimed at furthering the common good of the Karelian Bear Dogs. Trials and everything else … serve to make the bear dog even better than it is now" (a DP). KBDs are the driving force of activities: "The incentive comes from the dog world … dogs themselves have always set the requirements for development via the breeders" (a DP). The aim of the currently adopted systematic pure breeding is to maintain the breed's original hunting instinct, i.e. the dogs' ability to bark at big game, which was useful for "getting food for the pack" and still resonates well with the ways of life of KBDC members, such as hunting and various other outdoor activities.

Members of both communities voice a strong commitment and an intimate relationship with their domain of interest:

> "There is this curious dedication among LTER information managers to doing what we do, into getting data online, into looking at new technologies. Just meeting the objectives set to us by the NFS. These people are not doing it because they are paid well; it's more a matter of really believing in what we do." (an IM)

> "These kinds-of-half-outsiders do not have such a congenial spirit that would give the stamina needed in taking care of things in practice. The fact that one owns a dog and takes part in the community's activities brings certain personality and motivation

into the matter. If such affinity lacks, one is most likely to have a bit different attitude." (a DP)

Both communities operate within endlessly changing domains. LTER information managers provide data and technology support for ecological research, one inherent characteristic of which is that it – like all scientific enterprises – continuously reformulates questions and identifies new questions. On the one hand, there is the concern for having in place a data-safe, functional system for maintaining the integrity and availability of the long-term datasets. On the other hand, the incorporation of new capabilities for enhancing data's capture, use and preservation always holds the potential for an extra facilitation of science and its changing practices and needs. KBDC, for its part, is involved in trying to solve various challenges encountered in dog breeding (e.g., hip dysplasia and the heredity of the hunting instinct, a topic that is little studied in genetic terms).

In attempts to better understand – with the help of technology – the ongoing change processes that take place in the environment and the dogs, the communities have grown accustomed to collaboratively working towards their goals in a continuing manner. The following example of the KBDC's development of a new breeding method illustrates the steps needed in aligning various interrelated elements, such as existing knowledge, skills, means and methods:

> "when we used narrow mate selection we did not get good dogs … we knew of no better method at that time … then some started to do it in a totally dispersed way, they even imported dogs from abroad. That was not a good solution either, rather we needed a slow and sure way … it is of no use to try and look for instant prizes elsewhere, one does not get far that way … now it can be seen that we have gone towards broader mate selections, and I see this as important, that's the way it should be. We've got to continue in a gradual manner. … the new method and system provided a systematic and goal oriented approach and continuity … planning became more sustained and long-term." (various DPs)

Awareness of the long-term nature of processes provides an opportunity to develop communities with continuity:

> "The long-term has the advantage that you know that you are going to come back to things, or if a thread slows down or is dropped, down the road you can pick up that thread, because you will be on the same project … You will readdress something the next day, week or year. You are always related, affiliated, associated. LTER has that continuity." (an IM)

Continuity creates the trust within the community needed to be able to interact regularly, maintain reciprocity and collaborate in developmental undertakings (cf. [14]). These processes are hardly speedy ones because learning and designing proceed hand in hand (cf. [1]): new issues are dealt with as they emerge, and "knowledge and skills that were needed have been acquired and grown during the system design process" (a DP).

4.2. Nature—Technology—Community

Both communities are characterized by their close relationship with nature. This has, in interesting ways, contributed to their assumptions of technology development. As already quoted above, in the KBDC: "dogs have always set the requirements for development." Similarly, an LTER information manager describes the idea of ecology-driven technology development:

> "[it is] important that information management is driven by the research. Information managers continue to come back to assessing whatever [technology] projects they want to develop to whether it is really going to support the research."

The major issue, then, becomes to grasp what the dogs and nature are telling the technology developers [8], and how technology development is formed by the nature-technology relationship.

The communities' PD approaches interweave various ecological considerations, reflected, for instance, in their appreciation for nature's heterogeneities. In KBDC, this is expressed by remarks about the most essential joint activity: "preserving diversity is one of the most important things in KBD breeding … the gene pool must not be narrowed down, rather it should be broadened". In LTER, in turn, heterogeneities abound. They begin with different sites studying different biomes and ecosystems, and applying multiple disciplines in their research. The actual ways of conducting research are varied: "there are no two investigators at my site that work exactly the same way" (an IM). Ecological data is typically heterogeneous:

> "We have a lot of varied types of datasets. Some studies may have a ton of records, a 'deep database', not a lot of diversity, but huge volumes, like remote sensing. In ecological data, in general, you get much smaller databases that cover a much wider variety, 'wide databases'. In general you are struggling with the diversity of different types of data" (an IM).

Furthermore, many sites have existed long before becoming part of the LTER program, and thus have their own varied histories. Therefore, a wide range of organizational and institutional collaborative arrangements and social infrastructures exist. Historical reasons have also contributed to the diversity of technological infrastructures and technology strategies among the sites: "important for LTER information management … is an ability to deal with heterogeneity, not by limiting it but by dealing with it" (an IM).

Technology (development) is not seen as important per se, as the communities would continue their raison d'être activities even without modern technologies: "nothing has been done for the sake of IT nor only on its terms" (a DP). However, as information technologies have been developed to serve the communities' purposes, they have become thoroughly and complexly embedded and interwoven in them, forming artful integrations with other media, material, technologies and practices used in the purposeful, nature-related activities. In fact, the breeding of dogs can no longer be separated from technology, as expressed by a KBDC member: "what would be left if the IT part of breeding was discontinued or separated into an isolated unit? … it plays such an important role, and practitioners' expectations are high."

4.3. Domain—Data—Infrastructure

An important further aspect of the above nature-technology relationship in both communities is the essential mediating role of data between the domain and the technology, and how an appreciation and apprehension for data shape technology processes and infrastructure. An LTER information manager describes this:

> "The thing is that I have been there for a long time, and so have developed all those systems that deal with the climate data and particularly the stream system and stream chemistry … we have had these stream flow data, and our climate data, and some of

the survey data that we do from stream profiles, looking at changes in the wood and the streams, and changes in just the substrate, like boulders might get moved downstream and it changes the pool and ripple. Anyway, there is a lot about that survey … it has been going on so long that none of the PIs [principal investigators] are the ones that originally started it. So … you have a lot of these PIs that kind of get assigned, you might have somebody come in and he wants to use the hydrology data, so he is assigned sort of as the PI for the hydrology data … but he doesn't understand how it is processed or anything. So I end up doing all of the maintenance, all of the metadata, I mean that dataset wouldn't be a nice long term dataset if it wasn't for the data manager".

Securing a 'nice' long-term dataset by writing the metadata, i.e. data that describes contextual information about the ecological data, shows an intimate understanding of the data, their connection with the studied domain and data collection for research purposes, and of the data use practices of long-term ecology. All of these are held in relation to data as a technological construct to be maintained within the existing infrastructure. The comparison between PIs and information managers illustrates how well positioned the latter are to understand both the data with their connections to an actual domain and research, and to the technology used in processing and archiving data. 'Technical' or 'ecological' understanding alone cannot produce the actual structure and content within that account for the specificities of the domain and of the existing infrastructure.

In a similar vein, the importance of understanding the meanings of data, and shaping the domain-infrastructure relation accordingly, is visible in KBDC's information system development of using hunting trial data in offspring evaluations for breeding purposes, despite the common assumption that "hunting trial rules are good for measuring dogs' hunting qualities but not their inheritance" (a DP). By joining trial-data with dog-data through long enough time scales, and with a sufficiently wide sample of dogs (e.g. all dogs of productive age), statistical tools have been created for prognoses of hunting instinct heredity with the intention "to find out as early as possible the ability of dogs to pass down their hunting qualities to offspring" and not only in hindsight "after their production age has past" (a DP). The principle idea is that the younger the dog is when its hunting ability occurs the first time in trials, the less it has learned and the more it has inherited. It is difficult to compel, and time consuming to train, a young dog to hunt for and bark at game if s/he is not interested in it at all, or lacks the guts to be in front of big animals. The tools have further increased KBDC members' understanding of the complexities of inherited and learned characteristics in dogs and helped in estimating the environmental effects in hunting and hunting trials. The new breeding system with precocious females and males as mating dogs produces better quality and more numerous hunting dogs than the earlier system. The system "has made breeding founded on knowledge … not based on guesswork anymore" (a DP).

4.4. Use—Design—Practice

The intricate relations between nature-technology-communities suggest also a tight coupling between the communities' raison d'être practices and the use and design of technology. Members of both communities emphasize that understanding the domain is important in design. In the context of ecological research network, information managers underscore: "absolutely critical … you need to have enough understanding of the science, you are with scientists, you need to understand what would work for them and what not." (an IM) In KBDC, the domain understanding is reflected in the appreciation of expertise gained through participation in all practical activities of the community:

> "They [community members who build programs] understand what kinds of things we need because they have been participating all the time. They understand what is required because the needs are based on practical necessities" (a DP).

As domain expertise is highly valued, it is not enough for a member "to be eager and just sign up" as a technology developer. Rather, "one needs to have proven expertise … that people in the field trust and respect" (a DP).

In KBDC, the roles of use and design can be thoroughly intertwined: "the same person can be both a user and programmer", though weaker ties also exist: "I have not really done any programming, but I have provided a lot of ideas for design" (a DP). An ongoing precondition for the success of the combined role is expressed in terms of active participation:

> "There have got to be people who are in touch with, who know about the dogs. One has to have a personal relationship with dogs. I think one has to be active, either to own a dog, to participate in dog shows and hunting trials, or to be a judge. Then one knows, in addition to the computer side, also the other side … They complement one another." (a DP).

The role of LTER information managers with regard to technology and design is a complex one. They do not see themselves, nor do they have professional degrees, as software designers, IT specialists or systems developers. Quite on the contrary, they tell stories of "hot shot computer experts interested in cutting-edge stuff" who come in from "an environment of computer science and information technology" but almost inevitably move on within a year or two "because working at an LTER site they keep running into this impenetrable wall called ecologists" (an IM). LTER information managers themselves are located at the research sites, so they are firmly "embedded in a matrix of ecologists. And that gives them some special insights into what will work in their community and what won't" (an IM). There is a tradition of collaboration in technology design between scientists and information managers. The information managers realize the value of the "two way street between science and the techie" (an IM).

> "This … becomes effective in contributing to a learning process both for those who think they know the answers as well as for those that think they don't know the answers. This … has created an opportunity to bridge technology with science in a manner unique to LTER." (an IM)

Information managers increasingly find themselves in mediating positions between the professional technology design world and ecologists: "the critical role of mediators … the degree to which it works, has a lot to do with when you could get people who had a foot in both camps" (an IM). Within the LTER network, information managers are responsible for technology development. Furthermore, they are often seen as the proponents of technology within the network despite their rather unadventurous and 'feet on the ground' approaches to technology design. In their support role for ecological research, information managers are also very much users of the technologies they design. Furthermore, they educate others to use the technologies, and thus, they have a direct practice-use-design link available for evaluation and further design.

In KBDC, design often continues in use (cf. [11]). One of the self-learned user-programmers described how he got started in tailoring the system: "I just begun to practice … until I learnt how the code worked." As a result, he was later able to program "several new procedures, forms and reports into the database" and "as my skills increased, coding got easier, the code became shorter and there was not so much need for intermediate steps" (a DP). Another form of tailoring the system is co-operative sessions organized, for instance, in the context of annual meetings or for certain joint efforts as the following example illustrates. While four members are engaged in printing out the KDBs' previous year's results from the database, they also decide to deal with some programming and data maintenance tasks. One of the participants reminds: "before we move on, the bear test form should be fixed … what would be the easiest way?" Another, the most practiced user opens the code file and explains: "I think we can do it like the elk hunting form … as we go to the 'view or update a form' function … and open the form for the bear hunting test… the test's number is missing … it should be added … here we have to code a bit more, the 'look-up the bear hunting test' form." The third participant agrees: "yes, let's do it that way" and is reminded by the data at hand of a hunting trial event: "this data is about the elk hunting trial of Laaksonen's dog … it was recorded twice …". He recalls that the dog found bear tracks during what was supposed to be an elk hunting trial, thus the occasion turned into a bear hunting test. Now they have to make corrections to the data before printing the annuals. The fourth participant is eagerly listening: "I have to write down everything, so I'll remember." The practice of 'learning by doing together' offers an essential forum for interaction where various skills and knowledge are shared as part of tailoring the system. Moreover, the example shows how the system's use and design are thoroughly intertwined with the core activity and practices of dog breeding.

The blurring of boundaries between use and design characterizes both communities. Integration, local configuration, customization and redesign represent complex, densely structured courses of articulation work without clearly distinguishable boundaries [5, 22]. Participants' embeddedness in various ensembles and activities provides them with a range of perspectives over use, tailoring, training, modification, maintenance, reuse and design. This allows the developing of systems by closely accounting for the ongoing development of the raison d'être activities with which technology development proceeds.

4.5. Care Work, Ethics and Responsible Design

Technology related activities in both communities show concerns for both the biotechnical as well as the social system through care work, ethical conduct and practices of responsible design.

Ecological research typically deals with heterogeneous data and LTER particularly poses the challenge of the long-term for information management. Information managers are motivated in providing support for data, as they are aware that: "a database increases in value overtime if well maintained, even though it may lose some of the historic facts, the overall value will increase" (an IM). The long-term perspective is manifest in data stewardship through three temporal dimensions of data care work: information managers attend to the ongoing maintenance of core datasets, they anticipate and plan for the future, and they curate legacy data. Particularly, recovering the 'past' requires extra devotion as continuous prioritizing of what gets to be done with the resources available has to be exercised, and usually, more acute matters take precedence. One information manager describes his attempts to salvage some of the site's valuable data:

> "I was trying to document a lot of historic stuff and just asked the PI questions… he was coming on with Alzheimer's and I knew that he was going to retire … I had a series of interviews with him and I got INCREDIBLE docu, I mean, I got all the documentation for these early corporate data, all from just doing interviews with him" (an IM).

The excitement he voices for the success in gathering some of the historic metadata shows his contentment of having been able to prevent the loss of precious data. Efforts such as this one are precious, not only for the particular site's continued long-term studies, but also for global ecological research. However, nothing heroic is associated with data stewardship, rather the down-to-earth tasks are non-rewarded and under-resourced. The rationality of 'data care' associates more easily with that of, for instance, nursing chronically ill patients than the more typical rational models of technology design. Support for ecological research and stewardship of long-term data characterize an essential part of an information managers' everyday work. The rationalities of support and care work also 'set the stage' for technology design to be more judicious, modest and cautious, more responsible towards the long-term goals.

In KBDC, the ethics of dog breeding relate in complex ways to caring for and about the dogs. Specifically, the individual dog's needs, the breed as a whole, and the community engaged in the breeding activities are factors in the care process. In the 'Companion Species manifesto', Haraway invites us to think about the natural-cultural work of the co-evolution of dogs and humans where ethics is 'about significant otherness at every scale' [8]. This is manifested in the dog–owner relationship, where caring for the hunting dogs' good physical and mental health is important: "Dogs need to be taken care of all year around. You cannot take the dog out of the closet in the autumn like a gun; you live with it all the time" (a DP).

Similarly, breeders care about dogs as social and intelligent beings with natural needs to use all their qualities (cf. [9]). For instance, the animals' happiness is seen as a 'fulfillment of their possibility' [8]. In the KBDC, this 'possibility' is recognized in the quest to maintain the indigenous dog breed with its natural traits. As assessment of the hunting instinct is a complicated matter - the criteria for which has been formed within the natural-cultural world - the breeders account for several issues, such as a dog's health, conformation and appearance given in the breed standard. "It is important for many participants that the Bear Dog fairs well as a breed." (a PD)

Interestingly, the information system also promotes ethical conduct in dog breeding by making visible the actual practices of all parties involved in breeding activities: breeders, dog-buyers and breeding advisers, including the breed organization FSC. Through the various outputs of the system, e.g. breeding recommendations, the annuals, statistics of heath scanning, lists of new dogs with CoIs and their parents' achievements, breeder collations and the Web system which includes the dogs' pedigrees, all the members' breeding results, good or bad, are made public. This allows everyone to evaluate how each of the breeders follows the common goals of the community, what principles are valued in breeding, and so on. For instance, as soon as new puppies are registered, the breeding advisers can analyze their parents' qualities, calculate the puppies' CoIs (etc.) and see if the quality standard is followed. The community has been able to artfully infrastructure together data, ethics, information systems, long-term care work, and responsible design that contribute to sustainable development towards the desired future of KBDs.

4.6. PD as Tentative, Flexible, Open

Both communities do infrastructuring work in ways that are tentative, flexible and open, as suggested by Star & Bowker [20]. Their processes of Participatory Design are profoundly influenced by confidence in the communities' continuity (cf. [10]). This is manifest, for instance, in the trust of being able to return to and readdress things down the road, in the ways existing technologies and practices are accounted for in the design of new ones, and in the characteristically iterative development of technologies and practices (cf. [7]). In these communities, change is, as Suchman has put forward in relation to artful integrations [22], an aspect of everyday practice. Technology change is intimately intertwined with the changes going on in dog breeding and ecological research, as it is the dogs/ecology that drive technology development. Though change is ongoing, it is not necessarily a simple incremental process, nor a wholesale displacement and transformation. Rather, it is informed by enduring, tentative and open interaction between understandings based on the knowledge in the raison d'être domain of practice, in the experience of using and having developed existing tools, methods and technologies, and in the "leaps of faith inspired by imagination" [22] in envisioning new technologies. All of these are brought together into artful integrations in attempts to optimize for major changes in technological infrastructures which are interposed by interludes of more stable periods.

Another aspect that profoundly forms the communities' participatory technology design processes as a flexible one is their close relationship with nature. Natural systems pose tricky challenges for technology design. In LTER, various stories circulate about the recalcitrant and unpredictable objects of nature that defy the formalities of data collection and management, for instance, a widely dispersed one is of two trees at some point growing into one thus challenging the basic principles of data structures, and another one of a tree that the top got blown off in a windstorm and planted itself conveniently in the ground. The field crew tagged and recorded it, only to discover the next time around that it was falling over and had no roots [13]. Building flexibility for such insubordinate phenomena into the design of technologies requires an intimate knowledge of the objects of nature one deals with. Even this is not always enough, as often the occurrences have to be sorted out through the social system, such as in the above example of KBDC, when a hunting trial for elks turned into a hunting trial for bears as one dog traced the scent of a bear.

The communities rely on multi-voicedness and 'partial translations' [22] as social safeguards for flexibility and openness in their processes of infrastructuring, instead of primarily creating and enforcing technology standards. Though, of course, they are deeply entwined and reliant on standards which are essential building blocks in the development of working infrastructures. In fact, the communities are aware of their need to balance between standardization and issues of local flexibility [3]. An illustrative example of this in LTER is a tradition of constructing consensually agreed upon sets of principles or guidelines for the constituents of technical and social infrastructures, the so-called 'minimum criteria', that leave room for local variation as sites have legitimate historical reasons for differences in their technologies and approaches.

In KBDC, multi-party processes are shaped by the participants of the FSC meetings, the breeders and dog-owners, the Finnish Kennel Club in its central organizational role, and finally, the buyers of dogs. In LTER, participants include representatives of NSF, ecologists, field personnel, technicians and information managers. As it is practically impossible to involve all the parties and participants in any meaningful way all the time, several alternative ways to support multi-voicedness have been developed. For instance, both communities frequently apply a 'snowball model' of incremental participation as demonstrated by the LTER 'prototyping into consensus' and the KBDC CoI development examples. It often gets started by one member, is continued with a small group, gets then presented to other members, and is finally brought to evaluation by the entire communities in which all participants as decision-makers directly influence design. Furthermore, openness is reflected in the communities' practices of sharing and learning together. For instance, the above mentioned social mechanism for collaboration-in-design called the 'cherry picking octopus' illustrates how the information managers' community welcomes and is willing to consider all potential discoveries of technologies suitable for the ecological research domain.

Designing for flexibility is not an easy task and, in general, the required flexibility is emergent [20]. Both communities have developed and continue to develop various social arrangements in which to account for the interdependences of ongoing processes and the multiple divides within the participants' worlds (both technical, social and natural).

5. CONCLUSIONS

The cases support our presumption that studies of endogenous technology design 'in the wild' provide interesting alternatives in their insights, emphases, methods and practices to the more traditional PD approaches. KBD and LTER communities would exist also without modern technologies, but have integrated them and participatory design into their collaborative raison d'être activities in manifold ways over time. The blurring of boundaries between use, tailoring, maintenance, reuse and design, as well as attention directed to local, situated everyday practices with technologies, forms design as artful infrastructure processes which are tentative, open and flexible.

The notions of artful integrations and infrastructure have allowed us to analyze the cases in a more sensitive manner, more attentive to the multifarious relations and processes inherent in the particular communities of PD. Our initial hesitation with using the notion infrastructure, particularly due to its extended spatial reach and scope, to explore our cases has dissolved into realizing that the relatively small communities of LTER information managers and KBDC dog enthusiast-designers are complexly connected with their larger organizations, and their technologies are densely intertwined with other more general infrastructures. Furthermore, maybe even more importantly, it is the extended temporal nature of these undertakings as ongoing and longitudinal technology development efforts that closely relates them as infrastructure works. We see that the notions of artful integrations and infrastructure that highlight technology design as ongoing, longitudinal processes, rather than the short-term ventures typical in professional information systems development, and even in research projects with two-three year funding, are suitable candidates for the analysis of various kinds of communities and alternative ways of carrying out PD.

The notions of artful integrations [22] and infrastructure [21] have been (intentionally) put forward on a general level. As we have explored and used them in analyzing our cases, we can suggest some refinements to them in the context of community PD 'in the wild'. We do this below, in connection to summarizing related aspects of community PD upon which we have only been able to briefly touch due to restricted paper length. First, the nature-technology relationship is vast, complex and challenging, and we are merely able to note its almost complete absence in the arenas of information technology development and research, also from the notions of artful integrations and infrastructure. Communities with close relationships with nature summon for studies to be carried out in the messy, uncontrollable real world settings, far away from the typical enclosed sites of professional technology development.

Second, both communities vividly demonstrate the importance of data and the intimate understanding of data in all its relations with the domain and existing tools and technologies for the development of new ones. In fact, it would be hard to even think about technology development in these communities without the data that they are so dependent on for their raison d'être activities. We see the data-driven content-infrastructure relationship as a very central feature of community PD driven by practitioner-designers and note it is totally missing from the notion of infrastructure, and only implicitly available in artful integrations.

Third, KBD and LTER communities demonstrate responsible technology design. We relate this with their awareness of the long-term perspective and the fact that design is thoroughly entwined with other community activities, not an insignificant part of which can be characterized as care work. The ethics and rationality of care also permeate into technology and design considerations. The finding bears similarities with Suchman's suggestion in relation to 'located accountability' in technology design [22] where practitioners participate in situated design with their embodied, partial perspectives and personal responsibility.

The above refinements to the notions of infrastructure and artful integrations point to important areas of future research, together with the already stated need to carry out more studies of 'PD in the wild'.

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