Interaction Ecologies

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Abstract. In this paper we present one approach to understand palpability from the perspective of eco-systems of palpable devices. We will introduce the notion of Palpable Interaction Ecology that particular focus upon the properties that emerge from the interaction between people, their practices and palpable devices.

This approach is derived from research into the use of pervasive healthcare services that support women during their pregnancies. This is a situation where information is currently distributed among many parties. This makes it very difficult for the pregnant woman to assess her situation. To address these issues we have designed digital artifacts that support the pregnant women's information management as well as facilitating the interaction with healthcare providers. The concepts have been examined using workshops, user scenarios and low-fidelity prototyping through active participation of both healthcare personnel and pregnant women. The results of this work suggest that the proposed concepts have the potential to be incorporated both in healthcare and in the household routines if particular focus is given to understanding shifting needs and uses over time.

Visibility and invisibility, construction and de-construction, and supporting people in making computing palpable are among the important challenges facing the Palcom Project. Originating from the biology field, an ecology is often used to illustrate relations between an organism and the surrounding environment. We have in our case found a similar need to describe diversity in use situation and the interaction between invisible and visible information as well as the interaction of construction and de-construction of devices and data. A Palpable interaction ecology incorporates both a pervasive computing presence and the ability to add and subtract devices and data as desired. The ecology notion offers here an analysis unit of properties that emerge from the interaction between people and palpable services and devices. It is argued that by study how these ecologies emerged we could create a new understanding of palpable interaction and the making of palpable computing.

Keywords: Palpability, interaction, ecology

1 Introduction

The PalCom project aims at researching and developing a new perspective on ambient and pervasive computing named palpable computing (Palcom, 2004). One main objective for this project is to develop a conceptual framework for palpable

technologies and their use. Visibility and invisibility, construction and de-construction, supporting people in making palpable end-user compositions, and hence making computing palpable are some of the most important challenges for the Palcom project. One of the primary goals for the project is to demonstrate ubiquitous technologies with properties clearly available to the senses. Palpable systems should support understanding and user control regardless of the level of interaction.

We have studied the use of pervasive healthcare services to support women during their pregnancies. It is the result of a joint effort between healthcare professionals at the Skejby Hospital in Aarhus, Denmark and the Palcom Project. The concepts have been developed using workshops, user scenarios and low-fidelity prototyping through active participation of both healthcare personnel and pregnant women.

Our project on maternity care is one of several case studies within the PalCom project, where application prototypes were developed to inform the design of the PalCom open architecture. Our main interest was to investigate the impact and use of pervasive technology to support pregnant women and healthcare professionals. The conceptual framework developed within the PalCom project was used as a vehicle for the design and evaluation of the study and its results.

2 Case: Digital support during pregnancy

2.1 Background

Currently in Denmark, a pregnant woman is in contact with several different healthcare professionals in different locations over an extended period of time. This includes midwives, general practitioners, and in some cases various specialists. This situation has several implications regarding both the interaction between the different actors within the healthcare system and the pregnant woman (including spouse or other persons) as well as the addition and distribution of information.

Many data items are created during the pregnancy; some are valuable and necessary for the healthcare professionals, others are mostly of interest to the pregnant woman and her family, and some are used both by the pregnant woman and the professionals but for different purposes. Presently, the medical information is stored both on paper files and digitally on servers and local hard drives. The information is thus scattered between several professionals in different locations. This leads to a situation where some data is multiplied and updated independently, creating a need for synchronization. The current solution to this situation is a paper folder the pregnant woman physically carries with her containing all the necessary and updated information added at the various visitations.

2.2 Study outline

To acquire a deeper understanding of the situation at hand and to explore the different problems the women encounter throughout the pregnancy, various techniques and

methods were used and employed. The overall approach is rooted in the participatory design (PD) tradition (Greenbaum and Kyng, 1991).

The work could be divided into four main areas: ethnographic studies, inspirational workshops, functional prototypes, and evaluative workshops. In this paper we will draw on the results of several parts of this work, but focus on the lessons learned developing and using the prototypes, specifically from the perspective of palpable interaction ecologies.

Various types of field work were carried out within the study, including ethnographic observations at a pregnancy center. In this we focused on pregnant women with diabetes, using interviews and ethnographic 'shadowing' of the pregnant women, midwives and general practitioners to gain a better understanding of the current work practices and situation.

During the study a series of workshops have been held. The main idea behind these workshops was to bring practitioners and other users into the laboratory, where they could appropriate prototype technologies by working seriously on a particular, authentic job. The workshops were of both inspirational and analytical kind. The former was used for prototype conceptualization and iterative development, the latter included both analysis of information management and user experience as well as prototype interaction evaluation. Following the PD tradition we have used several different methods such as *Artifacts as Triggers* (Morgensen and Trigg, 1992) and *Future Labs* (Büscher et al, 2004).

To address the issues of social and artificial (via artefacts) interaction and information management, a number of functional prototypes were designed and evaluated. These were intended to support the pregnant women, her spouse and family during the pregnancy and the first time after birth as well as contributing to the professionals situation of e.g. a consultation (figure 1). These prototypes have been implemented to explore different aspects of pregnancy and maternity care practices that are likely to emerge using assemblies of innovative ubiquitous computing devices and services within the PalCom framework. They were used to determine what kind of assemblies users would wish to create, which data the different actors in our scenario need to have, to view and to share, as well as how the information should be presented.

Figure 1. Prototype concept

2.3   Palpable prototypes

There are major opportunities for ubiquitous computing and assemblies of various technologies within the domain of maternity care. In our case, these centre around (shared) access to multimedia information and support for collaborative articulation in many different settings. As a starting point for our work we proposed to supply pregnant women with a digital artifact, primarily intended for storing and communicating information. The idea is to 'augment' the pregnant woman with a network-enabled, modular, configurable digital artefact for holding and communicating information as well as interacting with other people and devices in the environment. Another aspect of the concept is aesthetic and is partly grounded in product semantics. It is intended to be an attractive artefact that could act as a congenial focus for the integration of experience in pregnancy as well as elicitate emotions of security, permanence and control regarding storage of personal and intimate information.

The design of this device built on the knowledge acquired from several different prototypes as well as the lessons learned during the workshops. These prototypes were produced in order to investigate various aspects of palpability. One dealt with displaying information on external screens, another challenged user interaction by providing a minimalist interface. Other were concerned with management of medical information. A third kind of prototype was used to investigate the collection and handling of personal and intimate information in the daily life of the pregnant woman. This prototype (prototype 2 in figure xx) deals with content production and handling and is the main prototype considered in this paper. It was implemented in two ways. Half of the pregnant women participating in the study got a prototype implemented on

a PDA and half got a low-fi mock-up in the shape of a scrapbook diary and a real stone. The primary task was to use the prototype to take notes during the pregnancy. That is, to write down what kind of data they would like to keep, how they would use it (e.g. to remember things to ask the midwife), as well as other things related to the use and content of the prototype. The duration of the test was two months and included two workshops, one in the middle and one in the end. In a third follow-up workshop, the findings of the pilot were discussed with the healthcare personnel (general practitioners, midwives, nurses and others). The pilot provided many suggestions on which data the pregnant women and their spouses were interested in as well as ideas concerning the design of the device itself.
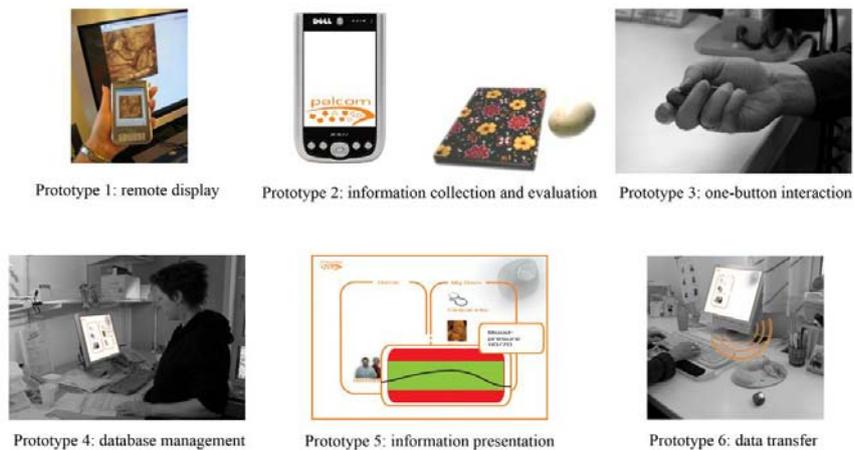

Figure 2. Prototypes

3   Findings

The key findings concerning the palpable aspects of our study can be described in two major themes: information management and distribution; and interactive and performative aspects.

One important lesson was the great variation in the individual circumstances and preferences of the pregnant women and in their contact with the healthcare system, and hence in the kinds of support they wanted and/or needed.

Another lesson was that the participants asked for an enormous range of features and functionalities, seemingly impossible to collect into one device (cf. Swiss army knife). This included both different kinds of information and media, various technical functionalities as well as functional simplicity and transparency of content.

3.1   Information management and distribution

The pregnant women reported problems with communication, both in respect to healthcare professionals as well as sharing information and experiences with their spouses. They felt that there is a lack of coordination between the different parts of

the healthcare sector, which in turn results in situations where the pregnant woman has to repeat the same information over and over again, a situation which is perceived as annoying and discomforting. Thus, there exists a need to facilitate communication between all parties involved, not only to avoid repetition and unnecessary redundancy of information but also to be able to prioritize consultation time differently.

The women also stated that information found on for example the Internet regarding the development of the fetus could be incongruent which was experienced as confusing. Thus they would like to have coherent and professionally revised information available on the device in order to avoid misunderstandings and anxiety.

An overarching discussion in study was a possible differentiation in the levels of information. For example, one pregnant woman suggested that it would be nice for the mother to be able to record the heart rhythm of the fetus. However, she also acknowledged that this could also give rise to concerns if the rhythm sounded odd or couldn't be detected by the mother. The specific interest and capability of the individual is thus a crucial factor to be considered.

The proposed device also introduces intimate information to be included at the same level as the medical data. This mix of personal and medical information on the device generates some new requirements about privacy and integrity (figure 3). It was for example notable that when collecting the diaries for evaluation, all subjects removed at least a couple of pages considered to contain information valuable but too intimate to disclose. Healthcare personal confirmed this by reporting that even if increased communication is desirable there are many cases where confidentiality has to be stressed. Hence different sets data need to be visible in some cases and invisible in others. Thus there is a need for clarity regarding data access control which is fundamental for the palpability when it comes to integrity and privacy.

Figure 3. Data display situations

3.2   Interaction and performative aspects

In Denmark and similar countries, a pregnancy is not normally a medical condition but could rather be considered a psychological, social and biophysical. The pregnant woman is not a patient, she is not ill in a medical sense and is not treated. The main concern of the healthcare professionals is to monitor the health of the mother and the development of the fetus. This has some implications when it comes to the possibilities of involvement of the part of the mother-to-be and her kin.

From our study we observed several aspects of this involvement. Firstly, the participants expressed a wish for co-creation of media and information selection.

Most of the participants were highly educated and used to personal responsibility and control from their own professional life. They expressed interests in adding personal annotations such as notes, images, sound recordings and video along with the medical information stored on the device. Some of them even explored the possibilities for making certain types of data collection at home, e.g. monitoring their blood sugar levels or their blood pressure, and thus contributing to their own and the child's health record. Moreover, the women wanted to prepare for the different examinations and pregnancy stages using the device. These ranged from reminder and timer functionalities to reviewing the purpose of the examination.

Secondly, the learning and information compliance were enhanced and supported by engaging the pregnant women and her kin in the information loop. Phenomenologically speaking, the knowledge became grounded in the lifeworld of the participants. Information was updated in dialogue with the healthcare professionals, not automatically synchronized. The information is thus commented and related to the understanding of the individual. It was reported in the study that it sometimes was preferred to have outdated information which is thoroughly explained by a professional rather than updated information which is left without comments.

Finally, in addition to the personal interaction level, the inclusion of an assistive device permits the user (pregnant woman) to interact with the healthcare information. This is currently not supported technologically by the healthcare system, which makes the interaction between healthcare provider and pregnant woman unequal. Using the device the pregnant woman thus gains tangible and explicit means to express, clarify, and communicate 'soft' data relevant within the specific context. This type of information is currently exchanged verbally and is mostly not recorded in any of the present healthcare systems. The device thus functions as a personal counterpart to the electronic patient journal in the interaction ecology and enables construction (and deconstruction) of personal information with the healthcare information.

4   Interaction Ecologies

The result of our work suggests that our proposed pervasive healthcare devices and services have the potential to be incorporated both in the present healthcare system and in the private household routines if particular focus is given to understanding shifting needs and uses over time. In order to understand and analyze the various settings and to describe the how to find a useful mix of both information and devices and services we would like to draw on the ecology concept. Ecology ('oekologie') as a term was coined by Ernst Haeckel in 1866 and is currently used to denote the scientific study of the distribution and abundance of organisms and their interaction with the environment. Traditionally, ecology is concerned only with living organism such as animals and plants. Gibson used the ecological metaphor when introducing the term 'affordance' in relation to the provision of abilities by things and organisms in the environment (Gibson, 1977). Here we would like to include human artefacts into this 'ecosystem', much in line with the sociological actant network theory (Latour, 2005). It is obvious that more and more human-made artifacts make dramatic impact on almost any ecosystem. Frenay compellingly summaries current trends and

the emergent need to rethink our relation towards technology and ecological thinking—with its fluid dynamics, its approximations and gradations; with its self-organization, shifting patterns, and awareness of widespread interconnections (Frenay, 2006).

Nardi and O'Day notes that the ecology term points towards that: "…technological development involves defining our own local information ecologies - creating a local habitation and a name for the technologies we use". They use the notion of information ecology to describe a system of people, practices, values, and technologies in a particular local environment (Nardi & O'Day 1999). In information ecologies the spotlight is not on technology, but on human activities that are served by technology. Suchman, et al (1999), use the ecology metaphor when proposing the necessary conditions for successful and innovative design, a more or less normative standpoint also taken by Norman (Norman, 1988). Luff et al have reversed the use of the term and talks instead about 'fractured ecologies' to address design problems in communication technology (Luff at al, 2003).

Nardi et al use the example of a hospital intensive care unit to illustrate an information ecology. All these people (doctors, nurses, etc.), machines (monitors, probes, etc.) and information (such as medical information, instructions and recommendations) — all have roles in the handling of patients. For us it makes sense to apply a similar perspective on our case of pregnancies to create an understanding of how various actors and artifacts form a context in which the pregnant women meet healthcare personnel.

In our case the information is currently distributed among many parties thus making it very difficult for the pregnant woman to understand and handle the situation. The Palcom project have been suggesting that construction and de-construction of devices and services is a useful concept to describe how to make computing palpable. Using the information ecology notion we can see that each context has it own unique mix of both information as well as devices and services to accomplish a specific task - at home, at the general practitioner, and the midwife clinic – and that finding this mix is a critical part of making a system useful. In ecological terms, it is a matter of homeostasis, a functional balance. This lead to that the construction and de-construction of information is yet another useful design dimension.

Moreover, we have observed that pervasive computing for healthcare services not only should focus on making information visible but also on interaction and integration of information – not only a passive consumption of healthcare information. This includes medical information, instructions, recommendations and other relevant data, as well as personal and intimate entries. In the use of the PDA and diary prototypes we observed that this combined set of data and relevant tools for producing, distributing and handling this information along with the individual's understanding, knowledge and experience creates a new meaning. We hence rather suggest that an interplay between visibility and invisibility creates meaning in the actual interactions which becomes a useful design dimension for pervasive computing. Here, we can also use the ecology metaphor to understand the richness of interactive relations and complexity of everyday interaction patterns (compare e.g. with Löwgren's use of inspirational interaction patterns; Löwgren, 2005). Krippendroff (2006) uses the term 'ecology of artifacts' as a description of how

artifacts are related to each other when talking about meaning. Krippendorff claims that in an ecology of artifacts, the meaning of an artifact actually consists of its possible interactions with other artifacts rather than the more traditional view on the individual usability.

These ecologies, constituted as a functional set of artifacts, people and the surrounding environment, in combination with the rich interaction between people and devices we identify as an 'interaction ecology'. There are many examples of these ecologies that help us through the everyday life, from the kitchen in your household to the city where we live. In this text we focus on specific situations observed in our pregnancy case. We argue that by using the ecology perspective we can get a further understanding of the nature and function of a palpable system.

In the analysis of our results we have developed a new analytical level that helped us expand our use of the Palcom challenges. An interaction ecology rejects the notion of simple design principles that create systems that are more simple, more invisible, etc. Accordingly, in an interaction ecology we must include the fact that users are in continuous dialogue with each other, as well as with distributed physical artifacts, and we must be aware of shifting needs and how those artifacts trigger and guide our actions in the world.

Invisibility	Visibility
Scalability	Understandability
Construction	De-construction
Heterogeneity	Coherence
Change	Stability
Sense-making and negotiation	User control and deference

Figure 4. PalCom challenges

5   Discussion

In conclusion, there are several reasons to why the ecology metaphor could be a fruitful one. Firstly, originating from the biology field, an ecology is often used to illustrate relations between an organism and the surrounding environment. The relations in focus here are between people's everyday practices and the surrounding infrastructure of information and communication technology available, for example electronic calendars, e-mail and messaging systems, broadcasted radio, music download services, e-commerce systems or on-demand television. In an interaction ecology, people are in continuous dialogue with a wealth of different services and their interfaces. Secondly, an ideal state for an ecology is one of harmonic interplay, where the relations between actors run smoothly without too much trouble. In an interaction ecology, this state of balance between people and artifacts could be characterized as a state of awareness and control. Hence, in a balanced ecology people are informed about the status of surrounding resources, they can bear with the attention demands from surrounding artifacts, and the ongoing dialogue is experienced as well in hand. Thirdly, people and artifacts in an interaction ecology

will show mutual dependencies, negotiating matters between themselves and with their environment, resembling the way different species are connected and dependent upon one another in a biological ecosystem. Finally, the balance of an interaction ecology – and the creation of meaningful relations – is the result of an ongoing and dynamic interaction between people and artifacts in the ecosystem. The interest in how people perceive their environment is prevalent also in a branch of cognitive research – the ecological way to understand perception. In this line of thought, the strategy for exploring and understanding how things work is interaction per se, and a threefold relationship between the individual, an activity, and the objects and surfaces of the environment is a central point of reference. Hence, the focus of interest when looking at interaction ecologies is the everyday meaning people ascribe to things and events they encounter, as well as strategies for how to act accordingly.

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