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Knowledge transfer and storage in mobile IT use for facilities maintenance

Abstract

Mobility and knowledge management theories have received rather little attention as related fields of research. Today, new mobile devices render new possibilities to interact and share knowledge. Taking a knowledge transfer and storage perspective, this thesis presents a minor ethnographic field study of mobile IT uses for facilities maintenance. This thesis discusses implications for mobile maintenance work. These implications are based on an extensive literature research combined with observations and interviews. When reviewing existing research concerning mobile IT support and knowledge management, in relation to my empirical study, I found that the mobile device must be embedded in the ongoing activities of the technicians. I also found that the mobile system supports knowledge transfer and storage in the sense that users could collect information from the system and put the information into practice.

Keywords: Mobility, KM, knowledge transfer and knowledge storage

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Master Thesis, 20 p.

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My work with this thesis began in the autumn of 2003, when I started to write an article for IRIS27 on a Ph.D. course in academic writing. The article was accepted and my interest for knowledge management and mobile IT evolved.

The contact with AirSon was established in the late December 2003, and they offered a truly interesting application area of mobile IT. I would like to thank AirSon and especially Ralph Klintner for your kind assistance.

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Tout est bien qui finit bien

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Lisen Selander

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1. Introduction

Since a majority of organisations claim that their most important knowledge resource exists within the company (Alavi & Leidner, 2001) new instruments for storing and transfer that knowledge is necessary. Mobility and mobile IT has become of interest not only for the mobile private person but also for industrial use.

Knowledge management focuses on areas such as knowledge intensive organisations and knowledge sharing between individuals and organisations (Walsham, 2001). Alavi & Leidner (2001) define knowledge management as four processes in which IT can play a significant role: knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application. In this thesis, I will concentrate on knowledge transfer and storage in relation to mobile knowledge systems.

The discussion about knowledge storage and knowledge transfer starts in this paper with Polanyi who in 1967 claimed that knowledge emerges in a dynamic interaction between focal and subsidiary components of meaning.

In his discussion of the firm as a distributed knowledge system, Tsoukas (1996), agree with Polanyi (1998) in that tacit and explicit knowledge are mutually constituted and should not be treated as two separated types of knowledge. Drawing on their theories this paper outlines some aspects of the possibility to use a knowledge perspective in design of mobile IT-support.

Previous research on mobile work by Fagrell (2000) and on local mobility by Dahlberg et al. (2002) has shown the possibilities and the difficulties in knowledge creation and transfer in different kinds of mobile work situations. Fagrell (2000) focuses on the importance of having information that can be considered “timely” i.e., knowledge that is relevant and immediately transferred when the user requires it, in a mobile work setting. Dahlberg et al. (2002) has a different perspective on mobility and knowledge. His research on local mobility focuses on interaction between the locally mobile person and other persons and artefacts.

Building on an ethnographical field study of a mobile maintenance system, aimed to support knowledge transfer and storage between service technicians, and a review of current research, the main objective of this paper is to *present a discussion of implications concerning knowledge transfer and knowledge storage in mobile work.*

The field study concerns service technicians and their work with the maintenance system AirSon V3i. The system was designed to help building supervisors, service technicians and industries to plan preventive maintenance of ventilation systems and production equipment.

One of the objectives with the system was to support knowledge transfer between co-workers and to facilitate the documenting process for the service technicians.

This thesis overarching research question is how to support knowledge transfer and storage through mobile devices and systems aimed to function in a mobile work setting.

The thesis is structured as follows: First I give an introduction to knowledge management, knowledge storage, creation and transfer. Second, I outline related research concerning mobility and knowledge management. Third, I give a background concerning the method I applied to obtain relevant empirical findings, followed by a deeper description of the AirSon V3i system and the work contexts. Fourth, I discuss and review the theories and present my empirical findings. Finally, I present my conclusions.

2. Theoretical Framework

Since knowledge has become such a critical issue for modern organisations the phenomenon of knowledge management has become a natural theme closely related to the subject. In this section, I present the theoretical background that constitutes the base of this thesis.

2.1 Knowledge management

There has been much emphasis in recent years on knowledge management (KM) and knowledge intensive organisations and societies. Many organisations have spent a lot of time and money on knowledge management initiatives trying to improve knowledge sharing and organisation. Although the ability to collect and process data increases, this does not necessarily enable improved human communication (Walsham, 2001).

Knowledge intensive firms focus upon knowledge as the most strategic important of the firm's resources. Grant (1996) argues for the important issue of integration and transferring knowledge, within the firm. Blackler (1995) suggests, in his discussion of knowledge, knowledge work and organizations, that attention should be given to systems through which people achieve their knowing, and on the processes through new knowledge may be generated.

Reviewing different approaches to mobility and knowledge systems, I find little research focusing on mobile knowledge systems with the exception of Fagrell (2000) and Dahlberg (2002).

Fagrell (2000) gives recommendations for how to make knowledge management systems support mobile work. Fagrell et al (2000) suggest the following features in development and use of mobile knowledge management system; first, support to evolve tasks interdependent of the user through shared tasks list. Second, create a system that provides a good overview of records to improve search quality. Third, create awareness and provide location of expertise through technology that can identify the location of, for example, a mobile device. Fourth, is filtering to help monitor user interests and tasks. Last, the aspects of configuration between mobile and stationary devices (ibid.)

2.2 Knowledge transfer and storage

Grant (1996) argues that knowledge creation is an individual activity and that knowledge integration and application of existing knowledge is the primary roll for knowledge intensive firms. In resemblance with Grant, Alavi & Leidner (2001) stress the importance of putting knowledge into practice. They define knowledge management as four processes in which IT may play a significant role: knowledge creation, knowledge storage and retrieval, knowledge transfer, and knowledge application.

Knowledge creation involves how new content may be developed or replaced within the organization. This happens through an individual's social, collaborative and cognitive process. Alavi & Leidner´s research on knowledge creation derives from Nonaka (1994) and his theories about the interplay between tacit and explicit knowledge. According to Nonaka (1994) interaction contributes to the amplification and development of new knowledge.

Knowledge storage and retrieval concern, among other topics, organisational memory and how experiences from the past influence the present organization. The communication processes and information flow in the organization is referred to as knowledge transfer. Alavi & Leidner (2001) describe four types of knowledge transfer: informal or formal, personal or impersonal. Knowledge application is grounded in the theories of Tsoukas (1996) and Grant (1996) and concerns the ability the organization to apply existing knowledge.

As pointed out in the introduction the discussion of knowledge, in this thesis, descends from the theories of Polanyi (1998,1967). He criticises, among other things, objectivism as untenable since it holds that the only valid knowledge is that which can be strictly articulated and tested. He described the relationship between tacit and explicit knowledge with the well-quoted words: " *we can know more than we can tell"* (Polanyi, 1998, 1967). He argues that some of man's most important knowledge is tacit and inexpressible like the knowledge of how to cycle or how to judge a work of art.

Nonaka (1994) claims that tacit knowledge can be transformed into explicit knowledge through externalisation. By this statement, Nonaka (1994), in contrast to Tsoukas (1996) and Polanyi (1998), means that tacit knowledge is the same thing as internalised explicit knowledge.

One issue that has been given much attention in knowledge management research is the relation and distinction between data, information and knowledge. Alavi & Leidner (2001) mean that knowledge is possessed information. Each person possesses information individually in relation to earlier experiences.

In contrast to Alavi & Leidner Toumi (1999) claims that knowledge must exist before information is created since information is knowledge articulated or verbalised. Knowledge must also exist before data so that data can be measured to form information (ibid.). This discussion often led to the distinction between knowledge and information.

Schultze (2000, p. 5) claims that

> *"Information is a flow of meaning and significance that changes a stock of knowledge. This change can occur either by adding to the stock of knowledge or by restructuring it in some way."*

In the discussion of knowledge and information I agree with Nonaka (1994) that information is a flow of messages that might generate, restructure or change knowledge. Nevertheless I claim, in contrast to Nonaka that tacit knowledge cannot be shared or expressed through a technology. I strongly believe though, that there is a need for technologies that might facilitate the sharing of explicit knowledge.

3. Related research

Several recognised researchers have explored mobile work and mobile knowledge. In this study I constitute my theoretical findings concerning mobility and knowledge management mainly on Fagrell & Ljungberg (2000) and Alavi & Leidner (2001). However Wiberg (2000) and Luff et al (2000) also contribute with important discussions to the related work in this study.

3.1 Mobile IT and Knowledge management

Knowledge management systems have according to Fagrell & Ljungberg (2000), the aim to support management of knowledge. This is usually done by systems that provide solutions to experienced problems. Knowledge management systems are kept updated by the users who add information to the system when new problems and solutions occur. They view knowledge management as a social and dynamic process that needs to be carefully considered and used in co-operation with workers to be understood correctly.

Local mobility is interesting from many aspects, the fact that a majority of organization claims that the most important knowledge resource exists within the company seems to be overlooked however the problem with identifying knowledge and transferring remains problematic (Alavi & Leidner, 2001).

Alavi & Leidner (2001) claim that design of information systems intended to support and augment organisational knowledge management should be rooted and guided by an understanding of different types and natures of organisational knowledge. Awareness about where knowledge exists in the organization is as important as the original knowledge itself. To evaluate the backgrounds, skills and expertise of individuals in the organisation is a valuable way to learn about the organisation as a whole (metadata).

Luff et al (2000) develops the thoughts about how to create technology that can be used and embedded within the many disparate activities of the user. They argue that one way to support mobility in organizations is to enhance an individual awareness of another's work although this effort has begun to raise problems in the design of the technological support. There seems to be a need to explore the possibilities and problems that arises when new organizational forms develop.

Dahlbom & Braa & Sørensen (2000) describes information technology as a flexible means of communication, by which social structures are formed, reformed and dissolved in a process of networking. Further, he compares the behaviours and structures of workers with that of nomads, i.e. people continually working on the move non-dependent of contexts.

In their discussion of mobility in collaboration, Luff & Heath (1998) argue that mobile services become necessary for supporting collaborative activities in modern organisations. Local mobility concerns according to Luff & Heath (1998), the movements of individuals in a workspace or area where technological support provides them with awareness of others and others of them.

Wiberg (2001) calls for more research on charting the social territory of the mobile worker, his work situation and the ability of technical tools to support the way people interact. Further he finds that there is a strong need for a home base when it comes to, computer supported cooperative work (CSCW) to support socialisation, experience-and knowledge sharing.

Fagrell et al (1999) argues that knowledge management in mobile settings is social and dynamic. Mobile knowledge management differs in many areas from local knowledge. In their empirical research they found following distinctions:

Sharing concerns how several people together share knowledge. This may differ in three ways, by ephemeral sharing, persistent sharing and story telling. Ephemeral sharing may occur when people meet to discuss their work and relate to others. Persistent sharing is a way to distribute information and is, to great extent, embedded in documents. The last way to share knowledge is through stories. Telling stories of previous problems and solution is a way of producing, maintaining and communicating knowledge.

Indexing is a way to share knowledge by relating to earlier experiences or recognizable objects.

Diagnosing is when people together seek to make sense of a situation or problem. This might lead to an agreement or a compromise.

Foreseeing is the way in which existing knowledge might be used to predict the future (Fagrell et al, 1999).

Fagrell & Ljungberg (2000) suggest some design changes in existing knowledge management system to make them work better as a platform for knowledge management: First evolving tasks, not static problems. Second, change the view of input to the system as dependent on each other, not independent.

Third, link the information from the repositories to the authors and make them accessible. Fourth, knowledge management systems need to look upon the user interest of the system as task-based, not only in short term but also in long term. Fifth, there is a need for the creation of a good overview of "hits" in the repository window. Sixth and last, users need stationary as well as mobile access to the system, not only from desktops.

Building on these dimensions Fagrell (2000) continues his research on how to make knowledge systems support mobile work. The following results were shown:

- *Knowledge is actively acquired by the user;*
- *Empirical studies of mobile work informs the design;*
- *The user can be aided in defining as well as solving the problems;*
- *Knowledge from many sources is integrated in a way that is tailored to the local use situation;*
- *Communication links between users and originators of knowledge can be established.*

(Fagrell, 2000 p. 149-150)

When I started my research process I was, inspired by Fagrell, determined to conduct my empirical work on a new application area for mobile IT. Though I mostly take a stand in the results of Fagrell, I apply the above reviewed theories in a new context with a focus on knowledge transfer and storage.

4. Research method

Since all research should have the aim to build knowledge the initial focus of my research was to gain understanding of, discuss, and examine the practical use of, mobile maintenance systems and work. This can be done in many ways from construction of innovative theories to observing and measuring devices. Qualitative research usually starts with an observation of a specific phenomenon. Within the field of qualitative research there are rich arrays of methods subsumed all with the aim to better understand a complex social phenomenon (Marshall & Rossman, 1991). The following section describes why an interpretative approach was appropriate in the light of the research problem.

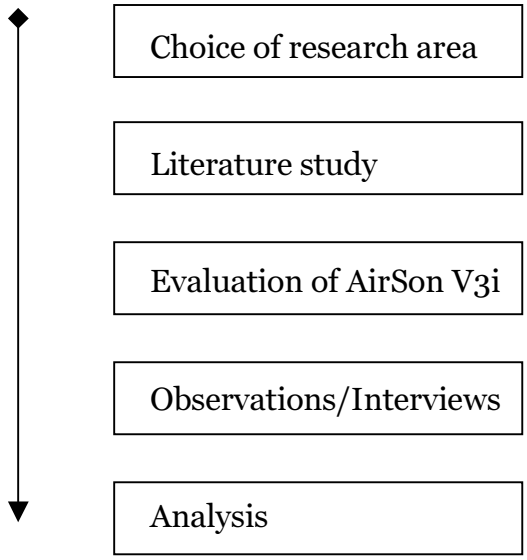
4.1 Course of action

My study was conducted in five main parts. I started my research process in October 2003 when I was introduced to the mobility field by reading an article by Dahlberg et al. (2002). However my main interest concerned knowledge management and organisational knowledge. I found the combination of the two fields of research in Fagrell's dissertation, Mobile knowledge (2000).

My literature study was mainly based on articles and doctoral dissertations and was conducted during the whole year of 2003-2004. I decided early that I wanted to conduct my empirical research in a context with traditionally rather limited IT use. I came in touch with AirSon trough a contact at the Halmstad University.

My first interview was conducted in February 2004 with the system developer and was the starting point for my evaluation of the system. I decided to conduct an ethnographic field study based on my wish to explore the work context as well as the practical use of the system. I had a curiosity concerning interpretative field studies and ethnographical research and a wish to learn from Schultze (2000). However I soon found out that the time spent on observations on the field, in combination with my inexperience of ethnographical research, was too short to render enough empirical material. I found it therefore necessary to combine my observations with interviews.

The interviews and observations were conducted during the spring of 2004. The empirical findings was analysed and discussed as a final part of my thesis.



4.2 Interpretative Field Research

Two main traditions appear when discussing methodologies and methods for how to conduct research within the field of IS, positivistic and hermeneutic research. Generally can IS research be considered positivistic if the results of the study is in some way quantifiable in variables, hypothesis testing, and if there is evidence of formal propositions (Klein & Myers, 1999). From the positivistic worldview derives the field of quantitative research. However a positivistic approach can also be applicable on qualitative research, for example case study research (Yin, 1994).

According to Dahlbom and Mathiassen (1993) positivists focus on knowledge that can be generalised e.g. finding empiri that can serve as a base for action on contexts that are similar enough. As believers in natural sciences, positivists analyse society in its most basic components.

Hermeneutic research, which was adopted in this study, derives from the Greek word meaning interpretation or theory of interpretation. In relation to positivistic research, hermeneutics stress the importance of participation.

> *"You can read nature like an open book if you know mathematics, Galileo claimed. The truths are there to be seen. But that is not reading, according to hermeneutics. There are no truths to be simply seen in a text. To understand a text you must interpret it. And all interpretation involves a dialectic interaction with another subject. Unless understanding is mutual, there is no real understanding, I can understand you only if you understand me".*
>
> Dahlbom and Mathiassen (1993, p. 219-220)

Klein and Myers (1999) claim that interpretative research help the researcher to understand human thoughts and actions in different social and organisational contexts. As interpretative field research has emerged as a valid and important research approach, questions about how its quality can be assessed. The field has been critiqued for the lack of generalisability however Klein & Myers (1999) suggest a set of principles to evaluate interpretative field studies.

4.2.1 Ethnography

Since my objective with the empirical study was to build an understanding of technology use in mobile maintenance work I found that an ethnographical approach seemed appropriate.

My research was conducted during the spring of 2004. Inspired by Schultze (2000) my first objective was to conduct a study primly based on observations. Since my observations became rather limited I found that I needed to combine my observations with interviews.

Since there lies a fairly widespread agreement in both management and IS literature that action and knowledge are closely related, an ethnographic study should pay attention to activities and practices of the object as well as to the context in witch the person act (Schultze, 2000).

I am well aware that the study that Schultze conducted included months of observations and work. The empirical findings in this thesis were collected through two observations during two days. The limited time spent in the field affects the study in a negative way. However I claim that my wish to conduct observations and study the activities and contexts in which the service technicians work was an important source of information to this thesis.

4.3 Data collection

Observations and interviews collected the empirical findings in this thesis. Conducting several smaller field studies seemed to be appropriate when the purpose was to cover the contextual conditions and use of the artefact. Since the time spent on observation was limited I also collected data via interviews, which became a primary source of data. The results that I present in this thesis are mostly drawn from interviews.

4.3.1 Interviews and observations

According to, Marshall & Rossman (1991) the fundamental perspective in qualitative research to uncover the participant's perspective on the social phenomenon of interest and uncover the participant's view on it, not the researcher's. Therefore, qualitative in-depth interviews much less structured than formal interviews. They are often based on a few general topics to help unfold the participant's perspective, often in the shape of a conversation.

My interviews were informal and differed dependent on my observations. I conducted one in depth interview with the system developer, to gain a better understanding of the system and three less structured interviews with system technicians.

Interviews are one of the most essential sources of information. The interview can take different shapes. Most usual are interviews with an open-ended nature. If the interview is executed successfully the role of the respondent could be considered as an "informant" who provides the investigator not only with insights but also with sources of corroboratory evidence (Yin, 1994). The purpose of an interview is to obtain valid and reliable information. It is a useful way to collect large amounts of data quickly. However, interviews also have limitations and weaknesses. The technique demand skills and co-operation from the interviewer as well as from the respondent. Interaction and the will to share information and knowledge are essential in the interview process (Marshall & Rossman, 1991).

When conducting an ethnographic study observation is the main data source. Direct observations on the field can reveal relevant information of behaviours and environmental conditions.

According to Marshall & Rossman (1991) can observations facilitate the process of gathering information on behaviours and the meaning attached to those behaviours in the social setting chosen for the study.

I completed two field observations in combination with three interviews'. My interviews were conducted after each observation and focused on the practical use of the system. I did an in-depth interview with the system developer and administrator of the system to reveal the fundamental objectives when developing the system.

The selection of interviewees was done on the basis of willingness and that they were users of the system. I am aware of that this study would have benefit from more interviews and observations with both users and non-users of the system.

4.3.2 Literature study

In this thesis the literature study constitutes the main source of information concerning the area of research. I have put a lot of effort in studying different areas of knowledge and mobility. My literature study has been constantly changing dependent on the review process of both my supervisor and in the review process to IRIS27.

Theory plays an important role in interpretative field research. According to Klein & Myers (1999) the theoretical background is a crucial device to distinguish the research from anecdotes. Further they state that:

> *"Nevertheless, it is important that theoretical abstractions and generalizations should be carefully related to the field study details as they were collected by the researcher. This is so readers can follow how the researcher arrived at his or her theoretical insights"*

Klein & Myers (1999 p. 75)

Marshall & Rossman (1991) identify four functions of conducting a literature review. First, it reveals the underlying presumptions behind the research and problem area. Second, it shows how knowledgeable the researcher is about related research and the intellectual traditions within the study. Third, it shows if the researcher has found a gap in earlier research that the study will fill. Last, embedding the problem area in a larger context will help to refine and redefine the research question further.

The literature study in this thesis constituted my own knowledge base when conducting my empirical research. This was a valuable way to gain a fundamental understanding of the research area and related research.

Since mainly Fagrell (2000) had explored the area I focused on his work to find other relevant literature. I felt a need to have a deeper understanding of the problem area to obtain reliable empirical data.

4.4 Critical observations

Not surprisingly there are several critical factors that have influenced the outcome of my study. First, I am aware that the limited time spent on the field decreases the reliability of the study. I restricted my observations and interviews to a period of time between Mars and April and I am sure that observations during a longer period of time would have yielded more reliable results.

Naturally there is also always a risk of miss-interpretation when translating interviews. However, I did my best to really understand what the interviewees expressed and revise the use of quotations. Finally my inexperience with conducting observations affected my efficiency on the field however it enabled a great opportunity to learn and reflect on my own research.

5. Description of the AirSon V3i system

The AirSon V3i was designed to help building supervisors, service technicians and industries to plan preventive maintenance of ventilation systems and production equipment. The system is divided into four subprograms: installation files, scheduling, spare parts inventory and costing. All four are included in the basic program and communicate freely with each other.

The system is built on a client server environment. The user logs in on an encrypted homepage with a username and password. The mobile device is a personal digital assistant (PDA) equipped with a bar code reader. Through the mobile device one can access all the functions of the system. The program is based on file cards for individual installations.

Particulars such as technical data, planned lifetime, replacement cost, spare parts and maintenance work are entered on each file card, from which required data are transferred to the scheduling, inventory and costing programs. There is also a possibility to add drawings and photos of the installation to the file.

The system is built so that it works even if the user does not want to use the mobile device, however the mobile worker is always dependent on some form of document tool.

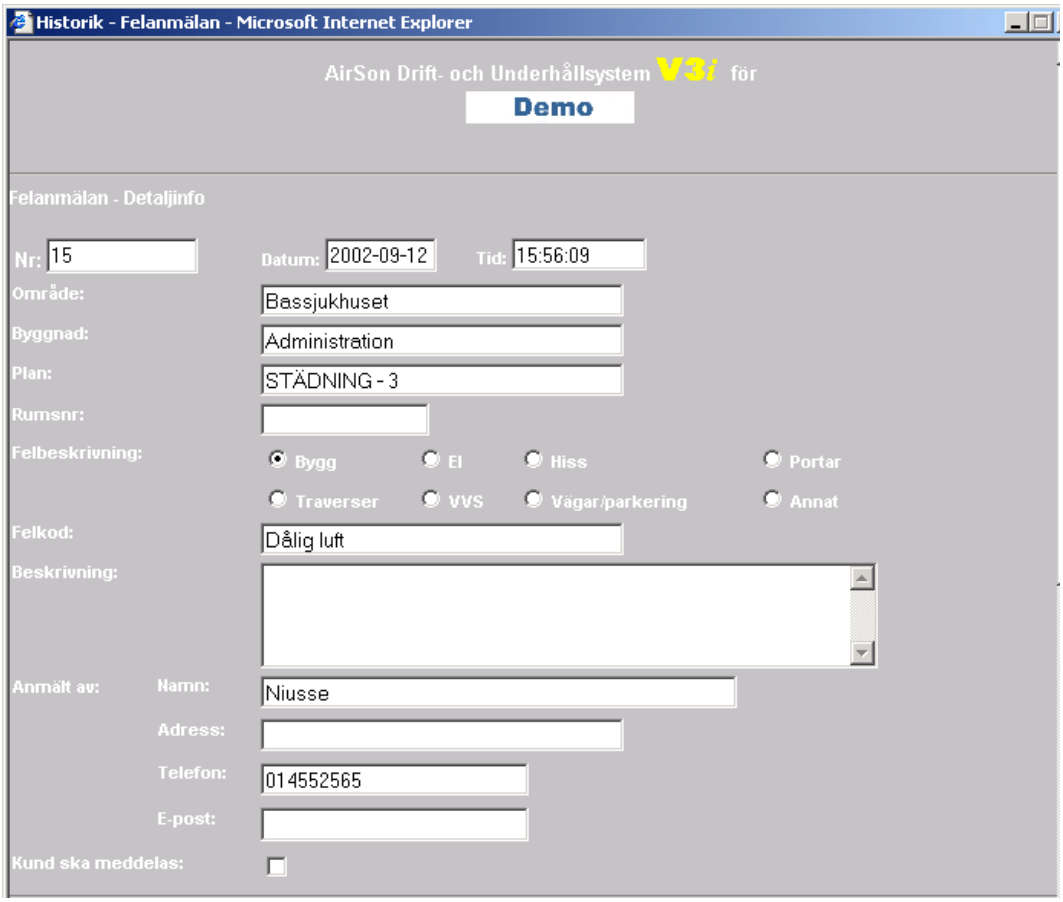
The system divided into four subprograms, as described above. All the different subprograms and the technical data are stored on an object card.

From the object card all the information is transferred to a program that plan the service technicians work. In this program the service technicians may print out service reports and forthcoming work objects. The technicians report to this program when they are done working with an object. The report is stored on the object card and documented as service history about the object. At the same time a note is made of what spare parts and other consumables that been used so that they can be subtracted from the spare parts inventory.

In the service history both technicians and property owners may control the different objects and preventive measures that been done. When an object has been serviced, the work order is receipted and comments can be added for future reference, providing a maintenance history.

The system developer described the system as an Internet based maintenance system for industry. The main purpose with the system was to:

> "*...facilitate the documentation process for the system technicians and thereby help the property owner to follow the working process of the system technician.*



The information process starts when the user logs in on the stationary computer and collects information about objects that need to be maintained during a limited period of time. However, the user is free to decide which object he feels necessary to service during the day. Information about the objects is thereafter sent to the mobile device (PDA). Two of the service technicians in this study had added a co-ordination system to the stationary system since their working context had so many objects spread over a large area.

When leaving their offices they decided whether to attach the bar code reader to the PDA or not. Since all objects were marked with a bar code, the bar code reader could help the technician with scanning the object direct to the PDA.

5.1 Evaluation context

The context in which my observations and interviews were done concerned one large industry. The observations and two of the three interviews were conducted in the same working context, "Pågens bageri" in Malmö. *Pågens bageri* is one of West Swedens largest industry that produces and delivers bread and cookies in Sweden and Denmark. The industry is ultra modern and has hundreds devices for heating and ventilation that need maintenance.

Due to the size of the industry, the service technicians worked over a large area spread over two parts of the city. They had an office and coffee room in the main building where their stationary computer was situated. The different objects that needed maintenance were situated both inside and outside of the building. The two service technicians that I interviewed on Pågen´s were both working as consultants.

6. Results/Empirical findings

AirSon V3i was developed with the aim to help service technicians and property owners to render better routines in their documental process. It was also developed with the objective to facilitate knowledge transfer and storage between co-workers. When I conducted my interviews and observations I tried to identify these areas in the work of the service technicians.

6.1 Fields of application

My empirical findings mostly concerned the gap between the goals of the system and the practical use of it. In order to illustrate these issues I used quotations from my empirical findings. The work settings of the different service technicians were similar in several ways though their expertise differed in different areas of *"VVS"* (heating, ventilating, plumbing, sanitary and refrigeration trades, insulation, energy saving and environmental and allied subjects.) Preventive maintenance, in this case, involved service and control of hundreds machines for heating and ventilation. These controls where conducted in certain cycles regulated by the system.

In this thesis, I used my observations to describe the practical use of the system in the context of the service technicians. The ways of working with the system differed in some ways although the overall impression of the advantages and disadvantages of the system were rather similar.

6.2 Design discussion

None of the service technicians that I interviewed and observed had worked with any other maintenance system before. Though they had used Microsoft Excel to document service reports. They all agreed on that the new system enabled them to update and document information in a much more effective way. However, they also claimed that the document process was not as time efficient as they had hoped. The time spent on documentation was much longer with the V3i system than before.

The mobile device was mostly used in the field since they all worked over rather big areas. Since they all were working as consultants they were rather limited in the use of the system since not all functions were applicable in their work context, e.g. the spare parts inventory. At Pågen´s there were several other maintenance workers whom the interviewees interacted with on a daily bases.

They often worked in pairs and communicated mostly through telephones or in face to face meetings. They were often able to handle each other's work though they had their own specialist knowledge. In combination with the PDA the service technicians also had access to a stationary computer, as recommended by Fagrell and Ljungberg (2000).

Service technician collecting information of the ventilation object in his PDA.

The respondents had a rather similar understanding of the benefits and disadvantages of working with the mobile device. Though they expressed uncertainty about whether they used the full potential of the system. One service technician expressed that:

> *" I do not use the full potential of the system today. I think it is a matter of time to feel comfortable with the system however we bought it two years ago."*

All but one of the users expressed that the main advantage of the mobile device was the possibility to easily update the system. He stated that the history function was the most important since it enabled an overview of the performed work.

I observed that when working with the mobile device the technicians got the information they needed from the last time that they worked with the object.

The developer and administrator of the system expressed the importance of improving the user possibility to share and document knowledge in and through the system. He expressed that:

> *"Our idea is to keep knowledge within the organisation. We want the service technicians to accumulate their knowledge in the system"*

All service technicians agreed that the documentation process had improved since the system was implemented. Though two of them claimed that the mobile device was too small and difficult to document through.

As Luff & Heath (1998) argued, mobile services in local mobility situations are necessary for supporting collaboration and awareness of co-workers. One service technician expressed that:

> *"The system mostly helps with the documentation of our work and increases the awareness of each other's work…if my colleague has called in sick I can easily see how to continue his work through the system. I am aware of his work context and, if he documented it correctly, the system will tell me what to do. We trust each other. "*

When asked if the system helped the service technicians to interact and share knowledge they stated that most of their interaction was through telephone or through spontaneous meetings in the coffee room. However they claimed that the system enhanced their possibility to store and transfer information. One service technician stated that:

> *" Before, when we did not have the system, I had to have all information of the different objects in my head, it was impossible to remember everything."*

I asked them of the negative effects with the system and they were all mostly concerned over their willingness to share their work process with the property owner.

> *"Today, when we work so frequent with documentation, we could easily be replaced. We were more valuable to the company before, however one cannot document everything, you have to have some experience and knowledge of the objects from before."*

One general negative reflection from the service technicians concerned the easily damaged mobile device.

> *“ The mobile device is too fragile in our work setting. Our hands are often dirty and we work both indoors and outdoors. If it rains one can not use the mobile device.”*

Two of the service technicians expressed that the system could be more adjusted to their own specific work setting. My observations showed that the service technicians worked frequent with the mobile device though they did not use the barcode reader. Further they spent a rather long time documenting since they used the keyboard tool instead of using the “text pen”. I observed the difficulties in storing the hand held mobile device while climbing different objects and working in a shifting environment.

I also observed that when they needed to communicate with each other they preferred direct communication through cell phones or personal meetings. They shared knowledge mainly through indexing as Fagrell et al (1999) discusses in their article. They discussed by relating to objects or earlier experiences.

7. Conclusion

Since a majority of organisations claim that their most important knowledge resource exists within the company (Alavi & Leidner, 2001) new instruments for storing and transfer that knowledge is necessary. In craftsmanlike professions like heating and sanitation one relies mostly on tacit knowledge and routine. The mobile device enables the service technicians to document their explicit knowledge. Though it does not help them to share their tacit knowledge.

In accordance with Fagrell (2000), Luff and Heath (1998) argue for the importance of creating technology that provide workers with awareness of each other though they have their main interests in collaboration and mobility support for interaction. I found that the service technicians exploited the possibility to control each others working processes. It helped them to communicate and augmented the trust between them as pointed out by Luff and Heath.

Information and knowledge seem to have a quite complex relation to each other. Knowledge management systems have the aim to support the management of knowledge, not information, according to Fagrell & Ljungberg (2000). The system was designed to store information about every object and the last service made on it. When the service technician came back to the object he would just have to check the system to see how to inspect the object. I mean that this is an example where information is transformed to knowledge when put into use. Alavi & Leidner (2001) stress the importance of putting knowledge into practice. According to them knowledge is processed information.

Fagrell (2000) expresses the importance of having information that can be considered “timely” i.e., knowledge that is relevant and immediately transferred when the user requires it, in a mobile work setting. The PDA enables timely information though there is a problem with the fragility of the system. The fact that the service technicians did not use the potential of the barcode reader is probably connected to the portability of the PDA.

Alavi & Leidner (2001) described four types of knowledge transfer: informal or formal, personal or impersonal. In this research context one might consider the AirSon V3i system to support formal and impersonal knowledge transfer. A challenge in further development of the system could be how to make it support informal and personal knowledge transfer.

I believe that in the review presented above there are several design implications that have been discerned. Although complex and difficult to consider in a design situation there is no doubt that mobile systems demand extensive design work to support knowledge transfer and storage.

While reviewing existing research concerning mobile IT support and knowledge management in relation to AirSon V3i I found that the system must not intrude the ongoing activities of the participant. The mobile device must be embedded in the ongoing activities of the technicians.

I also found that the mobile system supports knowledge transfer and storage in the sense that users could collect information from the system and put the information into practice.

8. Future research

I believe there are several areas that need to be explored in the area of mobile work. Future work concerning the interface design of the PDA would have been interesting. I believe that the system would benefit from more alternative communication possibilities in the PDA, such as a video or speech recorder. However, this is only an assumption from my part. I do not have more than indications on this.

It is interesting that the willingness to share and document knowledge is dependent on who benefits from the system. In this study I focused on knowledge transfer and storage between the service technicians, however it would have been interesting to focus more on the property owners and building supervisors in the future.

Additionally it would also be interesting to reveal, during a longer period of time, how individuals deal with the system that they are operating.

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Appendix

Design interview questionnaire:

1. Describe your job

2. What role/job description do you have in the organization?

3. For how long have you held this position?

4. How long have you been working with AirSon V3I system?

5. To what extent do you use the mobile device?

6. Is there a difference in the way you work with AirSon V3i in relation to earlier maintenance systems?

7. To what extent do you work in teams?

8. Has the mobile device changed the way you communicate with each other?

9. Has the AirSon V3i system effected the way you share knowledge between each other?

10. What experience do you have of the AirSon V3i system?

11. How often do you use the AirSon V3i system?

12. How do you use the AirSon V3i system?

13. What distinguishes the AirSon V3i system from the how you worked before?