INF5260 Final Report

Mobile Work – Mobile ICT Supporting Secondary Work

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Abstract

This report addresses one area within mobile computing that, so far, has received limited attention by researchers: The support of mobile work among non-office workers. To understand mobile work among such workers, we propose a framework focusing on primary and secondary activities. We used the framework on three different occupations: Nurses working within hospitals, home health care, and construction. The framework enabled us to uncover similarities and differences between these groups. We found that mobile ICT has a potential for supporting secondary activities of non-office workers. Based on these findings, we suggest actual applications and technologies for such workers.

Keywords: mobile work, framework, mobile computing, design of services, context of use

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1. Introduction

This report uses three separate case studies to explore an often-overlooked aspect of designing mobile systems: the fact that many mobile workers have a primary activity that does not include the use of computers. The use of mobile information devices is at best a secondary activity and the design of such systems must consider this. This is most evident in the case of manual labour, or blue-collar, workers.

Nurses, home-helpers, construction workers, electricians, drivers, all these, have primary working activities that do not depend on ICT. For example, nurses and home health-care workers primary activity is to nurse sick and take care of people in need of nursing, while the main task to construction workers is to build houses, buildings and constructions, and, of course, the drivers primary task is to drive. Strictly speaking, the majority of these workers do not even need information technology to perform any of their working tasks. However, mobile ICT might be useful if it supports or enhances communication, collaboration, and the primary activity.

Professional use of mobile phones is often associated with status and white-collar work. Many of the advertisements for mobile phones show people in business suits at airports and in meetings, busy making deals and arranging their appointments. Such users are typical representatives of users whose primary activities rely on the use of information devices[1]. Our case studies show that other users may have an equal benefit from the use of such devices. Discontinuities occur while performing the primary activity, and those are often costly and time-consuming.

We are proposing a framework to explore similarities and differences between different professions in order to understand and structure mobile work. We have used this framework on three distinct groups:

- Nurses
- Home health-care personnel
- Construction workers

We report on similarities and differences found, and we use them to formulate a set of guidelines for mobile application development for manual labour workers.

[1] See (Bergman 2001) for a definition of information devices

2. Background

Two and a half year ago, Jaquline Brodie and Mark Perry (Brodie and Perry 2001) wrote an article called "Design for Mobility, Collaboration and Information use by Blue-Collar Workers". Their article expresses concern about the lack of research on blue-collar workers as mobile technology users. They also argue that this is an important research area, and makes the following statement:

"Without this, how can designers and developers envision and create future mobile technology that will successfully support the dynamic, flexible and often urgent nature of the work that mobile blue-collar workers do? Fieldwork is desperately needed to ensure that the demanding nature of mobile blue-collar work is fully documented, and the physical constraints that any mobile blue-collar device will function under are examined. Attempts to design technologies that aim to support the communicative and collaborative activities of mobile blue-collar workers are likely to fail without this."

The article then describes a study performed on 15 blue-collar workers. The study is based on observations and interviews, and is mainly concerned with use of mobile phones.

Our study is motivated by the challenge presented by Brodie and Perry. In this report, we present a framework for mobile ICT, including three different case studies.

The fieldwork study of Fallman (Fallman 2003) is another study of blue-collar workers. Fallman also recognizes the fact that most previous CSCW work focus on white-collar workers.

Fallman focuses on the use of embodiment to explore the use of mobile information systems in industrial assembly sites. Embodiment[2], described as "*the property of through one's body being manifest within the world and hence inevitable a part of it*", is used to create support system prototypes for the assembly workers.

The fieldwork study took part in manufacturing units for Volvo Trucks and Volvo Cars. The prototype consisted of an arm-worm PDA, which had both context-aware[3] and context unaware functionality. The prototype allows the service technicians to locate spare parts, identify components, get component information, and provide access to component vendors by working as a phone containing an address list of the vendors. Instead of making the service technicians use a virtual pointer to find virtual components on their PDA's, real physical components are located by physically pointing at them. This is achieved by attaching a RFID reader to the PDA, and RFID tags to all the components.

A service technician's work is situated in the physical world. Through their findings, Fallman argues that the use of embodiment allows the service technicians to continue to collaborate in a way that is in line with their current work practice. By using an arm-worn system, the technicians are permitted to continue in the same physical sense as they are used to and at the same time get access to computational services and information.

We do not use concept of embodiment to the full extent, but the fact that the mobile devices should be close to the body, and preferably wearable is followed to some degree. Construction workers work in a rough environment usually wearing gloves. If they have to remove their gloves and wash their hands before interacting with a mobile information devices, that would itself introduce a discontinuity – which is exactly what we are trying to avoid. Embodiment is already used in a great extent by construction workers. Consider for example the clothing used by carpenters – it is designed for carrying tools and equipment and making it available anywhere anytime.

[2] For a more thorough introduction to phenomenology and embodiment, see e.g. (Mingers 2001)

[3] Context defined as the physical location they were operation at - detected by the use of RFIDs

In a way, one can also argue that Fallman's prototype helps the service technicians with their *secondary activities*. Their primary activity is to manufacture components, not to call vendors and locate spare parts. However, as the study makes no such inquiries, this might seem a little speculative. We do not have intimate knowledge about what really are the service technicians' primary and secondary activities.

2.1. Mobile ICT

This study suggests some possible applications of mobile ICT. We define mobile ICT as mobile devices used for interaction with an external computer based information system. Normally, such mobile devices use some kind of communication link to access the external information systems, but this is not an absolute requirement. In some situations, it is more feasible to download information at the start of the day and upload information at the end of the day.

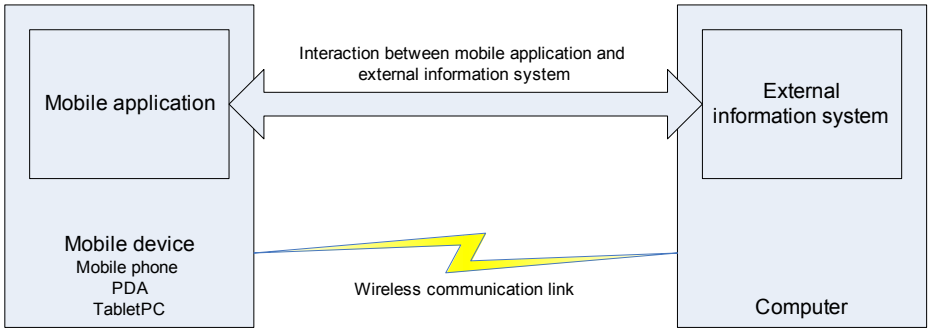

Figure 1 – Mobile ICT

We do not focus on traditional PC's and laptops, even if such devices may be used for mobile work. The rationale for excluding PC's and laptops from our work is that they are not constructed for being used while moving around – they are simply not mobile. Users have to sit down to operate such devices, and that does not fit in with the environment explored in our case studies.

We do not require mobile devices to be online at all times, but there must be some mechanism for data transfer between mobile device and an information system.

2.2. Mobile work and ICT

Mobile work is far-reaching in many business sectors and ICT has been used to support these workers. Mostly this applies to office workers who shift between different locations, like consultants, lawyers, salespersons, agents and similar. In these cases, laptops, PDA's and mobile telephones are often used. Blue-collar workers have traditionally had limited use of ICT. Examples of such workers can be carpenters, electricians, installers, plumbers, ship surveyors, drivers, nurses and home-helpers. These kinds of mobile work are required by the fact that certain places have to be visited, e.g. a ship, a hospital or a building site. *In this study, we focus on blue-collar workers or "non-office" workers. Often these workers have physical work and do a lot of manual work. We do not necessary always narrow down to heavy physical work.*

As in the field of computer supported co-operative work (CSCW), the environment of mobile ICT will have to support a heterogeneous assemblage of technology and organisational elements. In addition, it has to enable the physical and social mobility of computing and communication services between different types of actors (Lyytinen and Yoo, 2002). Mobile CSCW includes individual workers moving among several locations, and includes people working together may be physically separated. It implies that the location

shifts during the work. Wiberg and Grönlund (Wiberg and Grönlund 2000) define mobile CSCW as "*working together at various sites with the use of mobile IT*".

Effort is used on structuring and understanding mobile work and ICT, e.g. different frameworks are suggested. Julsrud (Julsrud et al. 2002) emphasize three conditions: the working tasks, mobility and existing habits and use of ICT. Lyytinen and Yoo (Lyytinen and Yoo 2002) emphasize four levels: individual, team, organisational, and inter-organisational. All levels comprised of both service and infrastructure development. The model of IT-use in mobile settings as Kristoffersen and Ljungberg (Kristoffersen and Ljungberg 1998) emphasize environment (e.g. physical surroundings, organisational constraints), modality (e.g. stationary, walking, wandering, travelling or visiting.) and intention (e.g. supported by technology –data and application).

Despite this effort, we find it necessary to develop a framework that focuses on mobile work outside an office. Our rationale for developing our own framework is that existing frameworks are to general, and cover more types of occupations than the non-office mobile worker we want to study. For instance, Julsrud's conditions seem to be to superficiality when exploring mobile work, or "working tasks" as they call it. Lyytinen and Yoo focus on different factors that are important to services on different levels, not on what mobile workers actually do, and Kristoffersen and Ljungberg model of the "wandering" is to narrow.

What if we try to focus on mobile work and less on mobile ICT, will we then be able to discover other aspects? For instance, what about primary and secondary working tasks? Nurses, home-helpers, construction workers, electricians, drivers, all these, have primary working tasks that do not depend on mobile ICT. For examples, nurses and home helpers primary task is to nurse patients and take care of people in need of nursing, while the main task to construction workers is to build houses, buildings and constructions, and, of course, the drivers primary task is to drive. Their secondary working tasks might be to receive and distribute information, create or follow-up issues, perform quality assurance, do reporting, collaboration and communicate with their colleagues.

In general, we see little support of ICT in these types of occupations. Therefore, their might bee a great potential of provoking radical changes and enhancement of current tasks, communication, collaboration, knowledge processes and other aspects in these mobile settings. We are in an opinion that in all probability, mobile workers will carry and use mobile ICT to support their secondary working tasks. For instance, the nurses will use a PDA to search for information about the patients, while the construction workers might use an advanced mobile telephone or similar, to communicate an issue of problem with the architect or the foreman that are on other places.

The rest of the report is organized as follows. In the next section, we present our framework for mobile work and in the three following sections, we present our three case studies; - nurses, home health-care and construction. For each case study, we structure them with respect to our framework. Then, in section 8, we discuss the result of using this framework and our findings. We conclude our report by summarise our work and findings.

3. Framework for Mobile Work

This section presents our framework for mobile work. By applying this framework to three cases, we focus on how mobile workers actually work. From the point of view of user-centred design, we try to find out more about how they work, the problems they face, and how they coordinate and collaborate with colleagues. Our assumption is that you have to understand their work in detail before starting to design and develop mobile ICT to support their work. We strongly believe that integration of mobile ICT with the work processes is a key success factor for mobile ICT.

In chapter 2.2 we described other frameworks, but these frameworks are more general, and do not focus on mobile work. Therefore, when diving into areas like "working tasks" (Julsrud et al. 2002), "services" and "different levels" (Lyytinen and Yoo, 2002) and "wandering" (Kristoffersen and Ljungberg 1998), these frameworks may be more appropriate. Still, our framework can coexist and augment these frameworks.

When trying to understand and discuss mobile work, and structuring mobile work into our framework, we aim to contribute by helping answering questions like:

- How can we design and develop mobile services supporting mobile work?
- How can we improve collaboration and coordination by using mobile ICT?
- Which activities are suited for computer support?
- How is it possible to utilize current functionality of mobile phones in mobile work?
- How can ICT facilitate knowledge creation and transferring/sharing of it?

Figure 2 is an illustration of a framework for mobile work. The framework focuses on the mobile work and it divides it into primary and secondary activities. Both primary and secondary work is categorised into four categories: 1) Work processes, 2) Complex activities and complex problems, 3) Lack of information and 4) Quality of work. Other issues are described under the section "Attributes" like organizational context, mobility context, knowledge types, and ICT skills. Aspects and details of all these issues are presented and explained below the illustration.

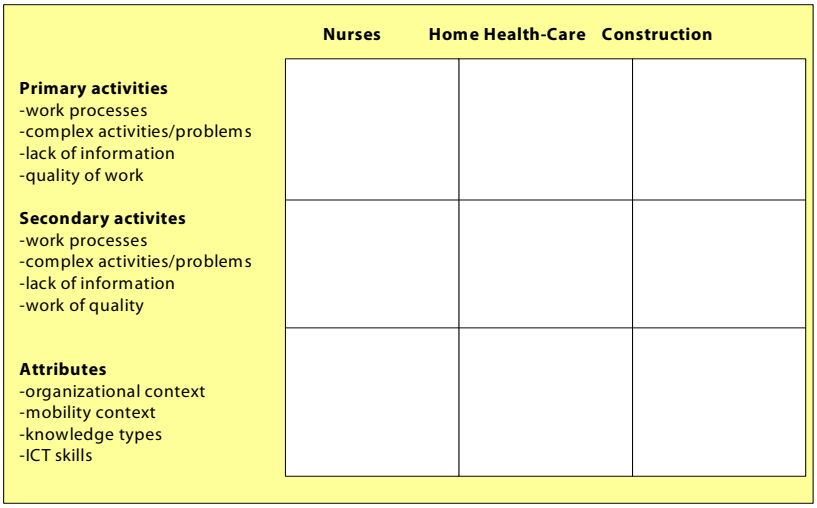

Figure 2 – Framework of Mobile Work

3.1. Primary and secondary activities

We define primary and secondary activities as follows:

> *A primary activity has a direct association with the primary objective of the work, while a secondary activity has a more implicit or indirect association with the primary objective.*

Secondary activities are often supportive of the primary activity. An activity may be viewed at different levels of detail. A primary activity within an occupation might be a secondary activity within another occupation.

To illustrate the differences between primary and secondary activities some examples are given. An example of primary activity is to prepare a patient before a surgery. This activity leads the nurse to move, clean and talk to the patient, i.e. the patient is the object. A primary activity in relation to this might be to read the patient journal, fetch the equipment that is needed and write a report when the surgery is done.

Another example is a carpenter building a wall. His primary activities are sawing, hammering and measuring. In this case, the wall is the object. Examples of secondary activities while building this wall could be fetching materials and discussing drawings with the colleagues.

Secondary activities are of particular interest in those cases where the primary work does not require assistance from a mobile information device, while some of the secondary activities do. Secondary activities are sometimes associated with discontinuities (Gershman, McCarthy, and Fano 1999) and bridging these discontinuities may be important to the overall performance of the primary activity. To explore detailed differences between secondary and primary activities we have categorized the work activities and work situation into four categories. The categories are meant to cover the breadth and the extensiveness of the activities and situations out in the field. Both primary and secondary activities are categorized into these. In the following, each category and their characteristics are presented:

Work procedures

Activities in this category are related to common procedures and routines, e.g. how the activities usually are carried out. Important characteristics might be how peoples are working together or if they are working alone. Do they share working tasks individually or within teams? Is the responsibility clearly defined or not? Which tools and which facilities support these activities? Are the procedures formal or informal? Are the routines documented? Are rules given?

Complex activities and complex problems

The activities are related to how difficulty tasks are done or what is happening when complex problems are arising. How are they solved and which actions are taken. These activities are typically not documented. Are they solved individually or as a team? Whom are contacted and why? What are done when exceptions and deviation occurs?

Lack of information

This relates to what people do when they are in lack of information. Do they search in certain places, or do they ask other people? This situation might happen when new tasks are going to be performed. Who are distributing information? Do formal or informal routines exist?

Quality of work

Activities in this category relates to how quality of work are accomplish and how quality is measured. For instance, is the quality assurance focusing on processes or products, or both? How are quality problems discovered and how are they improved?

Even though we are well aware that the boundaries of these categories not always are well defined and that the categories sometimes float through each other, our aim has been to test out this framework and see how it works with respect of our three different case studies.

3.2. Attributes

Due to its very nature, mobile settings are challenging many topics. An important start could be to understand and specify the context of use in mobile work. Context might be any information that can be used to characterise the situation of an entity, where an entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the applications (Dey 2001). In other words, context of use includes users, tasks, equipment (hardware, software and materials, and the physical and social environments in which a product is used (ISO 1998). In this study, the context of use at a general basis could be specified to include mobile workers that work outside the regular office, mobile services supporting tasks like communication, collaboration and knowledge processes. In addition, the workers have different degrees and patterns of mobility, they work in different degrees of exposed working environment, they will use small devices and many of the users are novices of ICT.

The different cases have different context of use. However, they seem to share the following characteristics: mobility, large diffusion on tacit knowledge and the users are ICT novices. We will shed some light on these issues in the following.

Organizational Context

Most workers do their work in some organizational context. Team organization is common, and is the normal form of organization our three case studies. Team organization does not imply that workers work together on the same task at the same time. Team organization is more an organizational umbrella for individuals working on different tasks, often in different locations. Team members often possess different skills and formal qualifications, and tasks are often transferred to other team members as the activity progresses. Secondary activities are often used to bridge discontinuities between such team members, and between different teams working on different shifts.**ICT Literacy**

ICT literacy is used to describe the skill level of employees regarding the use of ICT as a tool. In all three cases, a common denominator is that employees are normally not expected to have ICT skills. Their primary work does not require ICT skill in itself, but secondary work will be more effective and of better quality, if the employees use ICT.

Mobility Context

Mobility and context are broad and complex topics. Looking closer at mobility in mobile work, different patterns of mobility exist. Some patterns are already specified and discussed, e.g. local mobility in collaboration in a design company (Bellotti and Bly 1996), micro-mobility in hospitals, remote mobility at construction sites, and both remote and local mobility at London underground (Luff and Heath 1998), walking, visiting, travelling and wandering (Kristoffersen and Ljungberg 1998). Other important aspects related to mobile patterns, is to consider the roles of space and place (Harrison and Dourish 1996). Space is the physical structures and artefacts, while place includes the cultural meaning and use. Working activities are performed at different spaces, but a space can be a different place at different times.

Context might be any information that can be used to characterise the situation of an entity, where an entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the applications (Dey 2001). Terms like *context of use*, *contextual awareness*, and *context-awareness* are often discussed. For instance, the latter is devoted a whole special issue of Hu-

man-Computer Interaction[4]. Some try to related mobility and context, like Kakihara & Sørensen (Kakihara and Sørensen 2001) considers context to be a separate and important *dimension* of mobility. Agre (Agre 2001) takes this a step further, and defines a conceptual framework for understanding context. Agre argues that the breakdown of the traditional mapping between institution and place complicates the analysis of context. Agre's framework links the built environment (architecture), practice and institution.

As we see, defining exactly what mobility and context are and how to deal with it is not a simple task, and we do not try to do that in this report. When we consider mobility context we focus on the mobile patterns; *where does what happen*. This perspective might imply that people move and their work are performed at different locations during the day. We do not consider mobility as a question of distance travelled to perform the work, but recognizes the fact that the worker is not stationary, at her or his desk with fixed infrastructure.

Knowledge types

To support knowledge processes with ICT it is important to structure the different knowledge types and the knowledge processes (Alavi and Leidner 2001; Fagrell et al. 1999; Kucza 2001). Below is a description and examples of four knowledge types as (Alavi and Leidner 2001) classify them:

- **Tacit knowledge:** Knowledge that is rooted in actions/activities, experiences and engagements in a profession or a specific context (Polanyi 1966). This could be related to cognitive or technical tacit knowledge. An example is a process that requires a high degree of experience and creativity where the worker grasps and feels how to carry out the activity. Tacit knowledge is hard to communicate or distribute to other, and tacit knowledge is often learned through performing or action.
- **Explicit knowledge:** Knowledge that is expressed/articulated and generalized. An example is a clearly described process that states how to perform it. This could be based on a formal education, books, quality or work procedures, or similar. Often this type of knowledge is written and it can be communicated without actually having to perform or experience the knowledge.
- **Individual knowledge:** Knowledge that is created and inherent in a person. For instance it could be an activity that just one person in a company knows how to perform. Often, this is a type of tacit knowledge.
- **Social knowledge:** Knowledge that is created and inherent in collective actions of a group. An example is knowledge of how a team of people work and collaborate in curtain cases. Often this is a type of tacit knowledge.

Other types of knowledge[5] exist, but we have limited our discussion to the four types of knowledge mentioned above.

By applying this framework on three types of mobile work, i.e. nurses, home health-care and construction workers, we aim to understand and discuss them based on this structure and to come up with suggestions of possible use of mobile ICT. As a result of this process, we also hope to be in position to identify advantages and disadvantage with this framework.

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[4] Human-Computer Interaction, Volume 16, 2001.

[5] **Other type of knowledge types according to Alavi and Leidner: Know-how** - procedural knowledge, for instance, knowledge about how to perform a process that is to be carried out. For instance, this knowledge is communicated through routine wor, e.g. how to administer a particular drug. **Know-about** – declarative knowledge, for instance, knowledge about which tool to use or what drug is appropriate for an illness. **Know-why** – causal knowledge, for instance, knowledge about why a tool works or understanding why the drug works. **Know-with** – relation knowledge, for instance, knowledge about how a tool works together with different kinds of materials or understanding of how a drug interacts with other drugs. **Know-when** – conditional knowledge, for instance, knowledge when to use different types of tools or understanding when to prescribe the drug. Somehow related to tacit knowledge are also **embodied knowledge** (Mingers 2001).

4. Research Methods

We have used slightly different methods on the different cases. In the home health-care case, we have used observations and informal interviews with personnel and management as a basis for designing a prototype with support for secondary activities.

The construction worker case has focused on facilitating a rich and extensive data collection. That study is based on an ethnological approach. A mixture of qualitative techniques like observations, interviews, workshops, meetings, paper reviews, and other information sources like working process documents, checklists, and similar. The study has taken place at construction sites, e.g. particular behaviours in mobile work must be understood in their real settings.

In the nurse case, two basic methods for studying the nurse's activities were applied. One, interviews and studies of descriptions of formalised procedures, and observations coupled with grounded brainstorming sessions to discuss and interpret the observations. Second, exhaustive discussions have taken place within the group to find similarities and differences in the cases. Together with literature studies, this provides the groundwork for our framework and distinction between primary and secondary activities.

5. Case study - Nurses

This case examines mobility among nurses, secretaries and physicians at the surgical department at the University Hospital for North-Norway (UNN). More specific, we try to investigate if we can improve collaboration and coordination among healthcare professionals by using mobile information technology. If so, what are the critical factors? Which activities are suited for computer support?

This case is based on ongoing work with the UNN. Topics for discussion are: "Unwanted" mobility caused by an attempt at bridging discontinuities, problems with using modalities of mobility (such as local, micro, wandering, etc) as a means for providing inputs for systems design for actual applications, identifying and ranking primary and secondary working activities and finding out how these activities might tie up human resources (vision, hearing, hands, fingers, attention, etc).

5.1. Primary activity

Primary activity is to prepare the patient for surgery, provide care, assist patient while at the hospital, provide information to patient and next of kind, report on work and inform on any important observation or event related to a patient, and medication.

Artefacts have specific use, related to medical process or documentation.

The primary activity might be very difficult to identify, because it will change constantly throughout the workday. The day is typically structured through a series of tasks or assignments. These may be tied to one specific patient or related to routine procedures involving groups of patients within the ward. Two examples will be presented in this report. In the first example, the nurse must prepare a patient for surgery. This activity is described in a quality assurance binder for the department. The second example is a routine activity related to providing care for a patient at the ward in the morning. This is also described in the QA[6]-binder.

Work processes

Primary activity example one (preparation for surgery): (Short and much abbreviated version, as details would be outside the scope of this report). The nurse must make sure he/she knows the specifics of the surgical procedures and the requirements thereof. The patient must be informed and an evaluation of the general condition of the patient be performed. Cleaning and shaving of the patient might be necessary. Checklists are followed to make sure nothing is missed regarding allergies and previous experience with anaesthetics.

Primary activity example two (morning care): (Short and much abbreviated version, as details would be outside the scope of this report). The actual actions carried out might vary from patient to patient according to needs, but are based on a checklist of variables that will need to be checked. Individual adjustments are important out of respect to the patient. Some patients will require calm and peace and will request certain activities be postponed. Processes may include assisting a patient in personal cleaning and washing, checking how well the patient feels and note how well the patient has slept during the night. Checking the room and the bathroom for commodities such as towels and other artefacts is important. Preparing the patient for the morning rounds may be important.

While the first example follows stricter procedure plans, the latter is left more to the judgement of the nurse.

[6] Quality Assurance.

Complex activities and complex problems

Each nurse must take on a great deal of responsibility towards how to meet complex situations and complex problems. Some situations have clear plans, such as a cardiac stop, but most will have a degree of improvisation and judgement from the nurse. As most situations are not textbook cases, there is acceptance for this degree of improvisation, despite there being procedures for many typical exceptions. In more severe cases, there will be a debriefing to go through the situation and to go through the routines and procedures at the ward.

Lack of information

During the execution of the primary activities there are often situations of discontinuities (Gershman, McCarthy, and Fano 1999) due to lack of information (information discontinuity), requiring equipment or resources located elsewhere (spatial discontinuity), or not being aware of lab-reports or judgements from physicians being available (awareness discontinuity).

These are typical cases generating secondary activities and bridging these discontinuities is important candidates for designing systems available at the point of action.

Quality of work

Regular meetings at handover of shifts are part of the quality assurance in the ward. This requires the nurses to process and report information regarding the patients so that it can be formally handed over to the next shift. Report forms are filled out during each shift. Debriefings are important part of improving the procedures and finding consensus ideas for how situations should have been handled.

5.2. Secondary activities

Secondary activities may be handling logistics, make and receive phone calls and messages – make sure they are passed on to the appropriate person, report or retrieve information, keep stock of inventory and fill up supplies, etc.

Secondary activities are often created by discontinuities in primary activity or a result of trying to bridge a discontinuity.

Artefacts serve a more ad-hoc use: typically bits of paper to make notes and reminders.

Relating back to the two examples of primary activities it is possible to describe a few secondary activities to each of these examples. Because the work is a series of activities, sometimes performed in parallel.

Work processes

While preparing a patient for surgery, the patient may have questions that relates to remarks or judgement made by other nurses or physicians. This might make it necessary for the nurse to go and look for the source of this information or check reports and records to be able to give the correct response to the patient.

In other situations, there might be disruptions rather than discontinuities that create the secondary activities. Phone calls, other nurses trying to bridge their discontinuities, etc. may be the source of such disruptions.

Many of the secondary activities did not have the same degree of prescribed procedures and most were not described in the QA-binder. They had a very situated nature and often described as activities necessary to "make the wheels go round".

Receiving or bringing messages, checking information, searching for persons or resources, informing others, etc, are all examples of work processes resulting from secondary activities.

Complex activities and complex problems

One of the common problems experienced by nurses was to memorise all the pieces of information that the nurse needed to keep track of in busy periods of a shift. The challenge rises as things get busier, because nurses are then often more scattered, has less time for a quick chat or to pass on messages. It takes longer to locate people and the number of interruptions increases as the general activity level rises. On normal days, the number of nurses and patients are matched and the activities are within the margins that allow time for the secondary work. Nevertheless, there are days or periods where extra personnel must be called in to manage the workloads. One problem is that unlike industrial activities it is not possible to predict or control the number of patients that need help. Accidents add to the problem and may disrupt plans and the regular pattern of resources needed.

When accidents or other unplanned events disrupt or affect the planned activities changes and improvisations must be made. In short time schedules must be rearranged; people prepared for a postponed operation must be informed and taken care of, physicians may need rescheduling, post-operation wards must be informed, etc. This requires experience and knowledge, not only on the procedures but perhaps just as important: knowing the staff, understanding the implications of the changes and foreseeing the things that need to be rearranged in order to keep the wheels in motion and ensure safe and efficient treatment of the patients.

Lack of information

Many of the secondary activities are the result of discontinuities at the point of action. Information discontinuities are perhaps the most common source for actions that are required to "make the wheels turn" as one of the nurses described it. It is beyond the scope of this report to make a complete list of the situations and specifics of these discontinuities, but rather present a couple of examples from the situations described in the primary activity section:

Example 1: The nurse enters a patient room in the morning. The nurse knows the patient is supposed to get surgery that day, but is also aware that there might be some changes. The nurse warns the patient about the possibility of changes later in the day and says another nurse will come by later to inform and prepare for the surgery. The patient says that the doctor doing the rounds the previous morning had said something about some test results from the x-rays not showing what they had hoped and the patient has been lying all night worrying about this. The nurse then leaves the patient to find the doctor from the rounds the previous day and check on the reports from the radiology department. To do this the nurse needs to go to the nurse HQ to access a PC and to reach a phone to page the doctor.

Example 2: While tending to a patient later that day, preparing him for surgery, the patient asks a question that requires the nurse to go and check a piece of information with the nurse who checked in on the patient in the morning. The other nurse must be located and then asked for the information and then return to the patient.

These two cases show how secondary activities arise from discontinuities such as lack of information.

Quality of work

As many of the secondary activities are not described in the QA-binder or other procedure descriptions, there are not many structures aimed at developing how these activities affect overall quality of service.

5.3. Attributes

Mobility is an inherent part of most nursing activities. Where nurses move from one patient room to the next as well as to and from the HQ. Situation with patient requires full attention to patient and responding to the needs of the patient.

Most human resources are in use: hands, arms, torso, hearing, seeing, speech, and other senses + cognitive processing of all inputs.

The nurse must be able to mix everyday conversation and language towards patients and then process and interpret this into medical context and report in medical language.

Many nurses have a lot of experience with technology, but still feel alienated by computers and remain sceptical about using them.

Organizational Context

There are three shifts at the ward. The morning shift begins at 07:30 and ends at 15:00. The evening shift takes over and goes on until 23:00, when the night shift takes over. Most of the nurses are part of a rotation scheme where they over a few weeks have been working all types of shifts. This means that there are no fixed teams. Who you work with will change from day to day and from shift to shift. The number of people on duty varies as most of the activity is carried out in the day shift and the nights are usually quieter than the evening shift.

In this particular ward, the nurses were organised in teams in each shift, where each team being responsible for a geographical region of the ward (rooms were labelled with a colour code and the teams named accordingly: red, blue or green). Certain additional tasks would be assigned to each group, such as keeping inventory of towels and other routine tasks.

Much of the work and activities are carried out individually or sometimes two nurses will work a room together. This means that the nurse must be able to make decisions themselves and carry much responsibility.

A hospital ward is a very strict hierarchy and the execution of this hierarchy can sometimes seem strange and almost brutal to an observer coming from a different culture. The advantage of the hierarchy is that it creates clear command lines and roles. While these structures are generally adhered to, there are informal structures and hierarchies that may be seen as adaptations to the actual terrain. The efficient flow of work and activities depend not only on defined structures but also on how individuals execute their roles. A strong identification with the ideal of a nurse (or a physician) seems important in understanding how each individual adapt to the situation and may go beyond the initial and structural responsibility to make sure quality is high and humans are taken care of in an appropriate way.

The ward cooperates with several other wards, departments, and laboratories (most importantly radiology and clinical chemistry) as well as special teams and resources such as surgical theatres and the intensive care unit.

Mobility Context

Inpatient hospital wards are physically organised as a number of rooms of which some are places (Harrison and Dourish 1996) for specific activities (i.e. examination rooms with specific equipment or rooms for post-operation intensive care), some are offices (of some sort), while most rooms are patient rooms, accommodating one or more patients. Nurses do not generally have a personal office. Their primary activity requires them to spend most of their time with a patient or in between patients.

Mobility is important on many levels of observation. Nurses can walk several kilometres during a shift. As this is often related to the primary task, it cannot be expected that any sort of technology would change this. While providing care to a patient, local mobility (Luff & Heath 1998) is very important. Being able to move around the patient bed and often get in physical contact with the patient is vital.

Most wards have a nurse HQ or reception area where patients, healthcare professionals from other wards or departments, relatives and professionals within the ward may expect to find a nurse and be served or to be able to get help.

Nurses naturally move between the patient rooms and the nurse HQ. The HQ is a natural meeting place for formal and informal communication.

Most inpatient wards have some sort of information board where overview information on patients in the ward and the activity in the ward is displayed (this is usually a whiteboard, but other mechanisms may be used as well). The information on this board is often consulted to bridge discontinuities in the activities by nurses and physicians. Even nurses or physicians from other wards may consult this board before inquiring further information from local nurses.

As much of the activity is organised in activities carried out by individuals being able to make decisions at the point of action is very important. The point of action is often away from the HQ where the information resources are most likely to be found.

Cooperation across organisational (and implicit geographical) boundaries makes the mobility of nurses and other resources important. Access to information and communication mechanisms at the point of action may make a big difference in the efficiency of such cooperation.

Knowledge types

Explicit knowledge can be found in the QA-binders, forms, formal meetings and other procedures. Laws and regulations also represent explicit knowledge to some extent. The healthcare professions are mechanisms that ensure certain standards of explicit knowledge that can be expected by the various professions within the health care system. The strong hierarchies are supported by the unions of each profession and contribute to common expectations of the explicit knowledge for each person. The medical knowledge on anatomy, diseases and treatment are typical examples of such explicit knowledge.

Tacit knowledge and individual knowledge comes from experience and often plays an important role in the way healthcare professionals are able to improvise and deal with pressure and situated action. It is often difficult to uncover and understand the importance and influence of the tacit and individual knowledge. In the case study, we added brainstorming sessions where interpretations of the observations were presented, discussed and analysed in groups included key personnel. While working with the design of a system to support collaborative activities we often found it more important to rely on the tacit and individual knowledge rather than automating actions in the system. Decisions are often based on experience and judgement, relying on extensive knowledge of procedures, individual strengths and weaknesses among the personnel involved in specific activities are crucial to the efficient flow of activity in a situation where the situation can change fast and in dramatic ways.

Social knowledge is often interwoven in the roles and hierarchies of hospitals and within each ward. Ideals and high awareness of ethical issues probably plays and important part in this type of knowledge.

Much of the tacit knowledge is passed on through training with more experienced nurses and systematic training on procedures and situations in what may be called apprenticing arrangements. Inexperienced nurses have to be approved by senior staff before allowed to go evening or night shifts where the ability to make the right decisions can be more critical as there is less staff in the ward and only emergency cases are treated.

5.4. Possible use of mobile ICT

As part of the case study two different applications were designed in collaboration with a selected group of nurses and physicians. Most of the ideas for these applications came about as a result of brainstorming sessions where system designers and users were discussing and agreeing on the services to be afforded by the system, the organisational adaptations necessary and the actual design of the technology used.

The first application developed was called PASKOR and was intended to replace the information previously found on the whiteboard with a system using wireless LAN and personal digital assistants (PDA). The idea was to make overview information related to patients and key procedures in the ward available at the point of action.

The second application was called OPSKOR and was designed to make it possible to schedule the use of the two surgical rooms used by the specific ward and to be able to make corrections to these schedules as the situation might require last minute changes. In addition we made it possible to be able to report from within the surgical room to the outside how the ongoing operation was proceeding, thus making persons and teams preparing the next patient or post-operation procedures aware of the situation.

OPSKOR is in routine use today and is accessible on any terminal connected to the hospital network if the user has been granted access by the administrator.

PASKOR is in limited use, while a paper version is in daily use throughout the department.

It is very interesting to notice how PDA's are used or rather not used. While access at the point of action is regarded as important, the impractical size and weight of these older versions of the Compaq iPaq PDAs (with backpacks and PCMCIA-cards for access to the WLAN) make these mobile information devices impractical in actual use. This is particularly important with regards to the PASKOR application. A paper printout is preferred and used by all nurses on every shift.

The information in OPSKOR is not typically required at the bedside, but rather in offices and the nurse HQ. Some of the closest cooperation partners access OPSKOR from their own terminals. OPSKOR makes information available that would otherwise create disruptions and discontinuities. Plans are being prepared to make OPSKOR available to other wards in the hospital.

Other applications have been demonstrated but not fully developed due to lack of resources and funding. An application for registering observations and events linked to a patient, using icons for efficient data entry called POPicon may prove to provide important in helping nurses keep accurate reporting of these variables, rather than just remembering them.

PDAs may become accepted as a useful mobile information device when weight and size is reduced. Current versions of PDAs with WLAN built into the main unit have reduced size and weight by more than 50%. By integrating other services such as instant messaging and IP-telephony may increase the value of the devices and the services enough to lower the threshold of indignation to a level where PDAs become typical device for nurses to carry around. Some physicians are carrying a PDA with WLAN access to interact with OPSKOR and PASKOR as well as keeping personal information on appointments and emails.

The applications were developed as a series of active server pages (ASP)-scripts running on a web-server accessing the underlying database. This afforded a simple mechanism for adapting the user interface to different human-computer interface modalities. Most people access the applications from distributed PC-terminals. Adjusted screens are ready for PDAs. Paper printouts can be made for those who do not require real-time access to updated information and do not wish to bring along a PDA with WLAN card and backpack.

6. Case study - Home health care

Home health care is a municipal service. The municipalities are by law committed to provide adequate care for their citizens. Current best practice is to list these services in a service declaration. The service declaration tells clients and relatives what quantity and quality to expect.

The services will be different for each client. Some activities are directly related to the client (medication, feeding, personal hygiene); other services are related to the client environment (cleaning, shopping).

Like most public sectors, home health care services are affected by demands for efficiency and quality. Several studies have shown that ICT may improve both quality and efficiency. This case shows possible uses of mobile ICT within the home health care service.

Based on the framework presented earlier, we look for secondary work activities suitable for mobile ICT. To be able to spend more time on primary activities, it is necessary to reduce time spent on secondary activities.

Example: Today, after a thorough process to uncover possible improvements, City of Trondheim uses approximately 75% on primary activities and 25% on secondary activities. Other municipalities report 50% spent on each set of activities

This shows at least some potential for use of mobile ICT to improve efficiency.

6.1. Primary activity

The primary activity for the municipal home health care sector is to provide health care for eligible clients within the municipality.

Home health care is based on the needs of each individual client. The municipality offers a set of different services. Home health care personnel evaluate each client, and prescribe appropriate services. Examples of such services are:

- Practical help with daily tasks (personal hygiene, feeding)
- Practical help – learning how to perform daily tasks
- Medical care (treatment of wounds, medication)
- Food deliverance

Work processes

A home health care visit can normally be broken down to a set of individual tasks to be completed within a visit. Sometimes sequential ordering of tasks is required, but more often, the actual sequencing is decided by the home health care personnel.

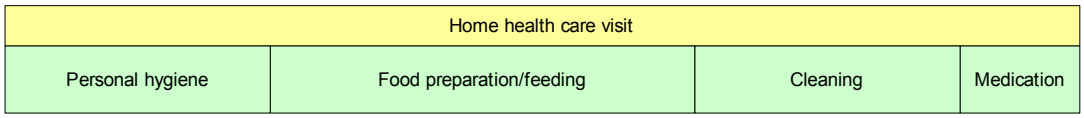

Figure 3 - Breakdown into tasks

The individual tasks are often described in detail, including instructions on how each task is to be performed.

However, it is important keep in mind that home health care is more than mechanical procedures. Clients also need needs comfort and support.

Complex activities and complex problems

Home health care personnel normally accomplish the planned tasks without experiencing problems. However, there are exceptions. Some activities are complex in themselves. A complex activity is not covered by the guidelines.

A second class is complex problems (exceptions). The most typical exception is a change in medical state of the client.

Complex activities and complex problems normally trigger several secondary activities.

Lack of information

Two types of client information are identified. Medical journal keeps information on health status, epicrisises and medication. Such journals are following a strict regime to ensure quality of information. Other information, like personal preferences of client, may be part of the health care information system, but may also be based on oral communication between personnel.

Lack of this kind of information triggers secondary activities, like contacting other team members to discuss situations.

Quality of work

The county chief medical officer makes formal quality inspections. Personnel are required to report any quality problems to superiors. Superiors supervise work. If quality problems are uncovered, both primary and secondary work activities may result. Examples: Additional medical treatment as well as personnel training sessions.

6.2. Secondary activities

The most time consuming secondary activity is travelling between client homes. Other important secondary activities are coordination, reporting, ordering specialist services, and training.

Again, secondary activities are often caused by discontinuities in primary activities or as a result of trying to bridge discontinuities.

Similar to previous case, artefacts serve a more ad-hoc use: typically post-it notes, binders etc.

Work processes

Work processes are often formal, e.g. reporting and ordering specialist services.

Complex activities and complex problems

Some secondary activities may be categorized as complex, since specialist skills are required, e.g. to order specialist services. Complex problems (exceptions) also occur. Complex activities and complex problems normally increase intra-team communication as well as communication with other parties.

Lack of information

Lack of information triggers activities to obtain missing parts.

Quality of work

Formal quality inspections by county chief medical officer include journals and other documentation. Personnel are required to report any quality problems to superiors. New secondary work activities may result. Examples: Journal walkthrough.

6.3. Attributes

Communication patterns

A care plan is the foundation for all service provision. The home health care personnel interact with the client throughout the visit. After a visit, results are reported. More sporadically, home health personnel needs to interact with other home health care personnel, relatives or other personnel (e.g. specialists).

The following figure shows the typical communication patterns of home health care personnel.

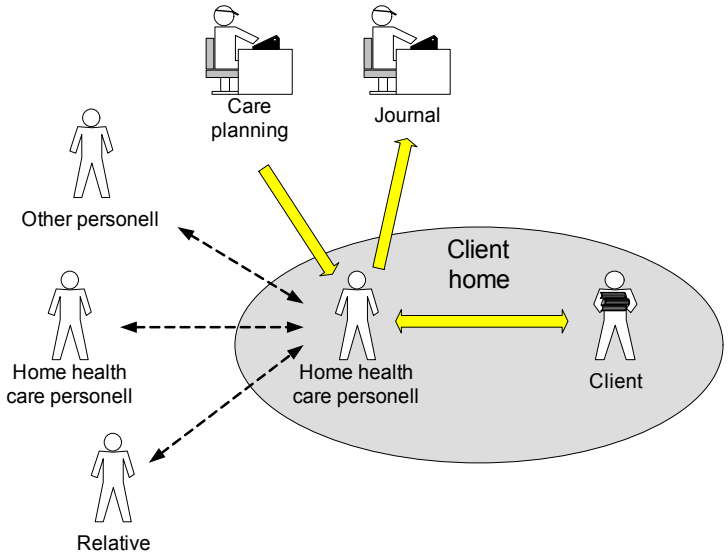

Figure 4 – Communication patterns

Organizational Context

It is common to organize the service in districts or zones that cover a distinct part of the municipality.

Multiple professions are involved in the service provision. Registered nurses take care of medical problems, while assistants take care of personal hygiene and cleaning. In addition, specialists are used for some activities like rehabilitation, hairdressing, manicure etc.

The workers are organized in loosely coupled teams. A loosely coupled team are working together to reach some goal, but they do not normally work on the same thing at the same time.

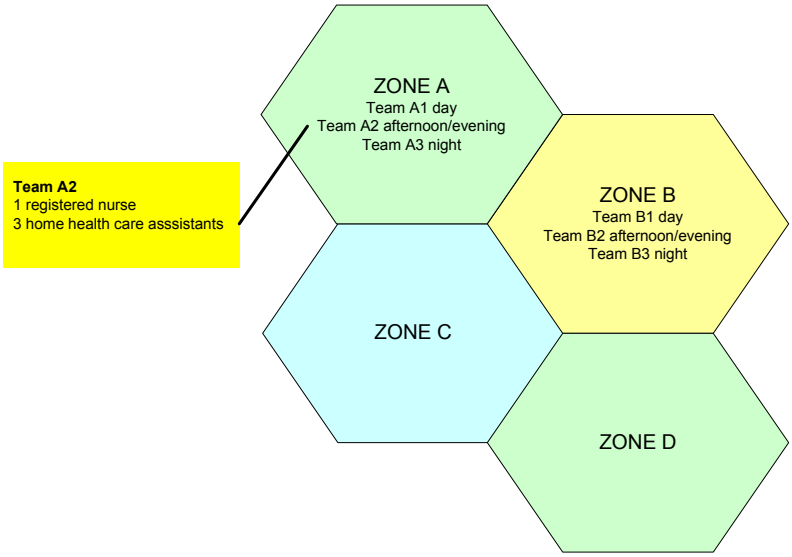

Figure 5 – Organizational context

Mobility Context

Mobility is an inherent part of most home health care activities. Clients normally live in their own homes, and are not mobile.

Home health care is mobile, since service provision takes place in the client homes. The health care work force is visiting several clients every day.

Knowledge types

Tacit knowledge is common. Procedural knowledge is often well documented as part of client care plan.

6.4. Possible use of mobile ICT

- **Access to client care plan**: Most municipal home health care services use ICT for administrative planning. Such systems make it possible to make daily detailed work plans for each employee. The requirements of the individual patients are based on client evaluation. Electronic access to work plans will reduce need for paper documents.
- **Access to medical documentation**: Can reduce need for paper documents. It is necessary to evaluate the impact on client privacy.
- **Statistics**: Enter start and end of visits. This can be used for adjustment of plans, and to keep track of where other team member are.
- **Team status:** Since teams are loosely coupled, it is necessary to have some kind of mechanism to inform the other members on status. The normal way is to have some kind of meeting before work starts, and some kind of meeting after work is finished. ICT may be used to facilitate transfer of such knowledge among team members.
- **Order specialist services:** Give the possibility to order specialist services.

The illustration shows one prototype[7] developed to show potential applications. It includes the three last points, and is easily expandable to also include client care plan on.

The main menu (3) includes menu entries for showing current status, write and read messages, show other team members, show information related to the patient, and order specialist services.

[7] The prototype was programmed by Jostein Topland under supervision by Lasse Berntzen

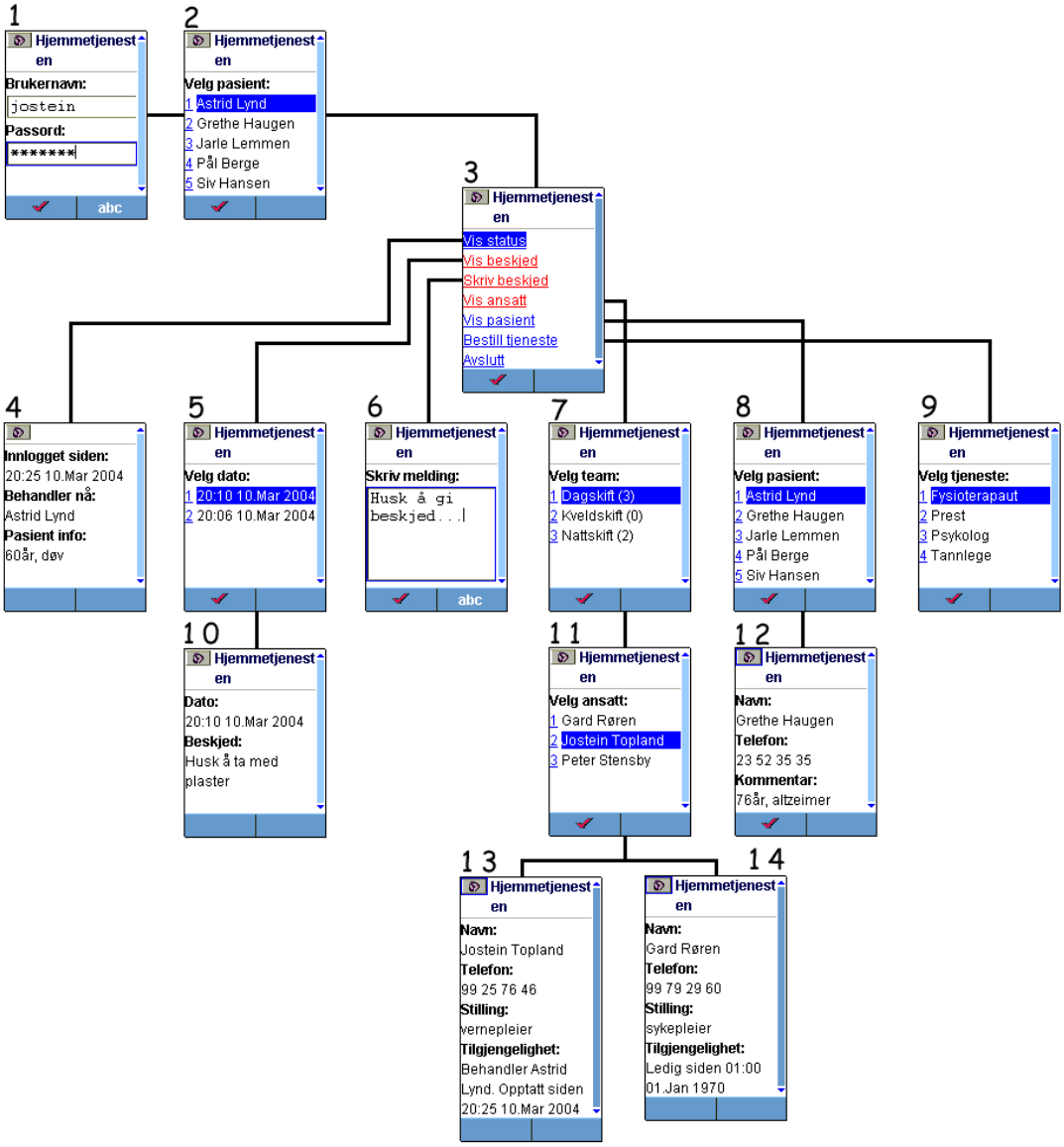

Figure 6 – Prototype application for home health care

One problem is the limitations on screen size and input mechanisms, which excludes use of applications that require large amounts of textual input.

7. Case study - Construction workers

Residential construction in Norway is a sector where competition and efficiency are on the daily agenda. Efficiency within construction meets many of the same challenges as in other manufacturing sectors. Examples are serial length (the length of the production set) and adjustments to the area/space, switch-over between series/production sets, choice of material alternatives and the degree of standardisations, judgment between large-scale operations and tailoring for a customer's personal requirements, and communication problems between different professions during production, e.g. concreters, carpenters, electricians and plumbers. Compared to other manufacturing, residential construction is still marked by small amount of series, low degree of standardisation, custom-made requirements, and a large diffuseness of competence and qualifications. In general, manufacturing is supported by ICT to a large extent. However, residential constructing is just supported by ICT in some areas. ICT is supporting the projecting and the design process in construction, but little ICT is supporting the work and the production at the building sites. Developing ICT to support the construction workers will influence their work and bring out new opportunities.

There exist many professions among construction workers, e.g. carpenters, concrete workers, electricians, plumbers, bricklayer, architect, digger drivers, crane drivers and dynamiter. This case study has focused on carpenters and concrete workers.

7.1. Primary activities

A carpenter's primary activities might be hammering, sawing, measuring and screwing. These activities directly involve construction of the desired building or object. To support primary activities within construction, the workers use a (pistol) hammer, a saw, screwdriver, or an inch rule. This equipment could be powered by electricity or not. At the moment, we find it hard to support primary activities with mobile ICT.

The primary activities to a concrete worker are to assemble and demolish concrete formworks, measure, iron fixing[8], concrete filling, polish, hammer drilling and concrete shaking.

Work processes

At a construction site, the workers are mainly working in given sequences. When drawings and the paper work are completed and authorized, the dynamiter and the digger drivers prepare the site. Then the concrete workers take over. When the platform of the residential building is completed, the carpenters can begin their work. When the casing is beginning to see its end, the electricians and plumbers are ready. Moreover, after that, the carpenters, the electricians and plumbers are working more or less in rapid succession. Gradually as each residence is beginning to see and end, the bricklayer may need to do a job, both on inside walls and the facade. All these processes are starting at the lowest floor and continue one floor at a time.

When it comes down to details for a carpenter and concrete workers they also are have their given sequences (it is out of the scope to describe these details).

There exist few documented routines, except from security routines. The routines are more of less built-in the teams and workers.

[8] Strictly speaking, an iron fixer could be classified as an own occupation, but in Norway they often work in team with the concrete workers, so we have chosen to let iron fixers to be classified as a concrete worker.

Complex activities and complex problems

A complex activity could be to start building a block of flats, e.g. understanding what and how to build. At this stage, the construction workers only have the drawings. Sometimes meeting between the architects and the construction workers are held, this in order to transfer knowledge and understanding. Another complex activity could be to find out how and what to build in a given flat, especially it this is the first time to build this kind of flat.

Examples of a complex problem could be the buildability of the drawings. Sometimes it is impossible to build what is drawn. Other examples are smaller mistakes and misunderstandings of the drawings.

As we have understood these situations, they all occur during primary activities, but the solutions to the problems mainly involve secondary activities.

Lack of information

At the moment we cannot identify the handling of lack of information as a primary activity. In a way, we can say that a construction worker might discover the need of more information while doing primary activities. This often happens caused by discontinuities. This again, triggers the need of doing secondary activities. Examples are drawings that lack important information or it will not give all detailed information needed. The latter is sometimes relevant if the architect use more time on details, than a carpenter need on building the construction/object.

Quality of work

The ganger and foreman are often controlling the work. They are mainly controlling the objects, e.g. the walls, the windows, the baths, the door stills, different constructions. The controls are performed by observation, measurement, and sometimes by use of physical power. In these cases, the activity of quality assurance seems to fit as a primary activity. If quality problems exist, the problems are usually fixed with a combination of primary and secondary activities. For instance, first controlling the drawings and if necessary correct the drawings, then repairing the construction either by tearing it down and building a new or by reinforcing the construction. In this case, the handling the drawings is a secondary activity and repairing the construction mainly involve primary activities.

7.2. Secondary activities

Examples of secondary activities to a carpenters and a concrete worker could be to report a problem, status or an issue to the foreman, to go and get some building materials or tools, e.g. handling logistics, to search for information, to prepare an electrical tool before use, to discuss a drawing together with colleagues, to perform quality assurance, filling working-lists. We see possibilities to support some of the secondary activities with mobile ICT.

Work processes

Secondary activities might be to coordinating the many teams at the construction site. The construction workers are frequently searching or going to fetch tools and materials. Both coordination and keeping track of the logistics are challenging topics. Another example of secondary activity is reporting. The reporting is often done verbally, e.g. the ganger comes and asks about the status. There exists minimal of documentation and how to do these activities are left to the judgement of the worker.

Complex activities and complex problems

When complex activities or problems have occurred, the workers often discuss the drawings with colleagues and the foreman. Other times they learn from each other or they simply try out new solutions and see how they work.

While looking at the drawings carpenter normally discuss what to build and the concrete workers discuss how to build it. This is because many of the carpenter's tasks are very detailed, while many of the concrete worker's tasks are related to large construction and how to crane the large form elements.

Some of the problems are reporting to the ganger, and the ganger decides whether the foreman should be notified or not.

Lack of information

If the workers are inn lack of information they often study the drawings, discuss and communicating with other people at the site.

Quality of work

Often the processes of work at a construction site are measured bye working with support of checklists. The checklists focus on the processes, e.g. whether and how a job is performed. The construction workers checks his own work and the sometimes the work of the predecessor. At this stage in our process, we would classify the use of checklists as a secondary activity, e.g. controlling the work not by checking the object or the construction that is build. In the cases where the workers actually check the object, this should be categorised as a primary activity. However, as we observe them these borders are blurred.

7.3. Attributes

Organizational Context

In Norway, the organization structure at construction sites is often hierarchic. In figure 7 you will find and illustration of such a hierarchic structure. Starting at the right of the illustration we find the carpenters, concrete workers, electricians and plumbers report to their ganger. A ganger exists for each profession. The gangers report to the foremen of each profession, while the foremen report to the clerk of works. The clerk of works reports to the to the project leader. On the left side of the illustration, we find architects or engineers for each profession. They report to their common leader whom also is an architect/engineer.

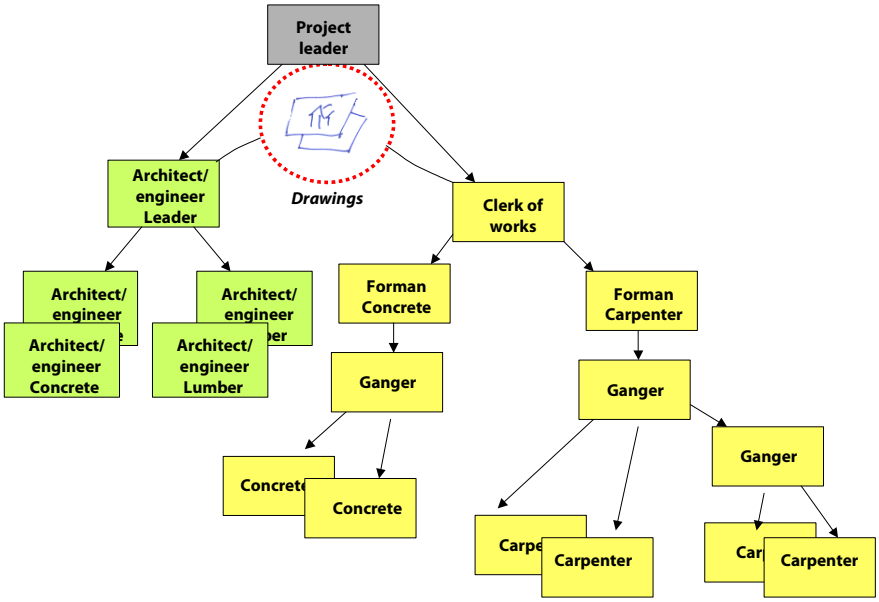

Figure 7 - Hierarchy

The organisation structure is quite formal, but we find a more informal culture among the teams in different professions, e.g. the ganger is "one of the guys".

It is worth mention that the hierarchic structure might vary with respect on the size of the building project. If it is a larger project, you might find two more project leader, e.g. a project leader for the architects and a project leader for the construction site. These will report to the main project leader. In addition, you might find many gangers that report to a ganger. Normally, a ganger has responsibility of 10-12 members. If its more than this, a new ganger is designated to report to the main ganger.

In order to visualise how the drawings are important in this structure, they are added in at the topmost of the illustration, marked with a circle. The drawings are the requirement specification of the buildings that are going to be produced. The transferring of the drawings is sometimes done during a working meeting where participants are the leaders of the architects, the foremen, the project leader, the clerk of works and the gangers. Obviously, the transferring and understanding of the requirement specification is a critical process.

During construction of the buildings, the foremen sometimes contact the architects when needed.

Mobility Context

The workers at a construction site almost move constantly and in addition, their work is very physical. They move inside the building they are building and between different sections in the building. In addition, they go between different buildings. Sometimes they go to the construction hut to communicate with foremen. In addition, they go and get materials or tools that sometimes are placed outside the buildings and other times are placed inside different sections in different buildings. They frequently move between different buildings. During working hours, they rarely leave the construction site.

Knowledge types

During a field study in construction (Skattør 2003) it became evident that a large diffusion of tacit knowledge (Alavi and Leidner 2001; Polanyi 1966) among the workers existed, and that the work was heavily based on earlier experiences. The study also showed clear traces of individual, social and procedural (know-how) knowledge, and more sporadic traces of declarative (know-about), causal (know-why), conditional (know-when), relation (know-with) and pragmatic knowledge[9] which is useful knowledge or best practice for an organisation. A lot of the critical knowledge is "stored" in the drawings (Skattør 2003) and the communication of this knowledge is therefore critical. At the same time some distance and boundaries between the designers/architects and the contractors/construction workers exist in constructions (Bowden 2003; Skattør 2003).

Fagrell and Kristoffersen (Fagrell et al. 1999) are pointing out four different aspects related to knowledge processes in mobile work that is electrical workers in Sweden. They structured the processes into a knowledge management system consisting of: *sharing, indexing*, *diagnosing* and *foreseeing*[10]. All this aspects was also found among construction workers (Skattør 2003).

Novice ICT users

Within construction quite little ICT are used. Exceptions are mobile telephone (Julsrud et al. 2002; Skattør 2003) and radio/walkie-talkie (Bowden 2003b; Skattør 2003).

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[9] These terms of knowledge types are referring to the work of Alavi et al. 2002.

[10] Fagrell and Krisoffersen (1999): ***sharing*** - several parties exchange knowledge, ***indexing*** - one party explains to another which knowledge to retrieve, ***diagnosing*** - two parties make sense of a situation, i.e. how it should be interpreted, ***foreseeing*** - one party or more uses knowledge to project the future.

Since site personnel are ICT novices there is a preconception that unless hand-held computers are found to be usable for them, the uptake of these new systems will be slow regardless the benefits available to these individuals and the project team as a whole (Bowden, Thorpe, and Baldwin 2003).

7.4. Possible use of mobile ICT

In contrast to primary activities, many of the secondary activities might be possible to support with mobile ICT. At this stage of the study, we see the following areas of utilisation:

Communication and collaboration between the project and the production. As mentioned, a lot of critical knowledge is "stored" in the drawings and at the same time some distance and boundaries between the designers/architects and the contractors/construction workers exist in constructions. In general, in current construction projects there is a little communication and knowledge sharing between the project life-cycle phases. ICT might be a major element that allows seamless information between the phases.

Improved communication in a life-cycle phases through visualisation. Since communication between the construction parties relies mainly on drawings and specifications, visualisation makes communication more effective and accessible.

Knowledge and experience retrieval, storage, and transfer. For instance reporting problems or issues. If a carpenter discovers that errors exists in the drawings, defects with the materials, something is missing or consumed, errors in construction, these issues could be registered on a handheld and reported.

Use of past knowledge in new development. In construction, it is essential to rely on past project knowledge and information when dealing with new projects.

Logistics: The construction workers have an over-complex logistics. Due to limited space at the construction sites, they store different equipment and materials at different places at different times. They use a lot of time to search for equipment and materials. Possible solutions could be with use of RFID or similar, in relation to a system of logistics.

Quality assurance: As we have seen, the construction workers are using checklists when they perform quality assurance. The checklists are paper based. These checklists could be "ported" to an electronic version, for instance, on a PDA or an advanced mobile telephone.

Coordination of the activities and time-handling: Because of many occupations at the construction site and the high degree of difficulty to achieve an overview of the status of whom is doing what when, a mobile system could be made for the construction workers where they could report their status of activities continuously. This could be made for a handheld or similar. Today the construction workers uses paper lists when taking down their working hours, also, these lists could be "ported" to computer program.

8. Results and Discussions

8.1. Results mobile work

The following table summarises our three case studies. Nurses are notated with "N", Home Health-Care with "H" and Construction with "C".

	Primary	**Secondary**
Examples of activities	N: - Prepare patients for surgery, monitor health status, perform tests, provide medical care and medication, communicate medical information to patient. H: - Provide medical care and medication, cleaning and other household tasks, food preparation and feeding, help with personal hygiene. C: - Hammering, sawing, measuring, polishing, concrete filling, hammer drilling.	N: - Logistics (keep track of patients, equipment, test results), communicate with relatives, retrieve patient information, report on work, handling messages, (re-)scheduling. H: - Travelling between client homes, coordination among team members, ordering specialist services, report on work, training. C: - Report on work, report problems, logistics (keep track of equipment, tools and materials), search for information, and coordination among team members.
Work processes	N: - Both strict procedure by using checklists and follow her/his own judgement. H: - Detailed descriptions, including instructions on how to perform different tasks. C: - Sequences of activities and professions, starting at the bottom and go upwards, not documented, but built-in team, except from safety rules.	N: - Disruptions, triggered by discontinuities, less prescribed procedures. H: - Disruptions, triggered by discontinuities, formal routines. C: - Judgement, verbally, built-in, no documentation.
Complex activities/ problems	N: - Individual judgement, clear plans, debriefing. H: - Change in medical state of the patient. C: - Starting with new buildings or minor construction that is new, buildability of drawings. Solved through secondary activities, individually or by team.	N: - Memorise all details during busy periods, heavy workload and accidents might lead to improvisations. H: - Trigged by primary activities, order a specialists, intra-team communication. C: - Trigged by primary activities, discussion with colleagues, looking and discussions over the drawings of what and how do build, reporting.
Lack of information	N: - Arise through discontinuities. H: - Arise through discontinuities and exceptions. C: - Drawings, discovered during the activity and arise through discontinuities.	N – Triggered by discontinuities in primary activities. H: - Trigged by primary activities. Information found in medical journal, home health care system, or by contacting other personnel. C: - Trigged by primary activities, discussion with colleagues, looking and discussions over the drawings of what and how do build, reporting.
Quality of work	N: - Regular meetings at handover of shifts, debriefing, reports. H: - Formal quality inspections. C: - Checking the product/the construction.	N – Not described. H: Regular meetings at handover of shifts, debriefing, reports. Also triggered by primary activities, formal quality inspections of journals and documents C: - Controlling the activities with use of checklists.

Table 1 - Findings

This comparison shows similarities and differences between the three different cases. The primary activities are very different. Working with patients in a clean, tidy hospital environment is conspicuously far from working with tools and materials at a dirty, noise-filled, outdoor construction site.

However, we find interesting similarities in the secondary activities. Secondary activities are often used to bridge discontinuities arising from work handover. The typical situation is reporting as a mechanism of information transfer from one worker to another. Secondary activities are also triggered by the need to

perform complex primary activities, sudden discovery of unforeseen problems, or by information deficit. We also witness that many primary activities involve physical or manual work, while secondary activities involve communication, collaboration, reporting and handling papers or documents

All three cases show use of formal procedures manifested as checklists, flow diagrams and other documentation on how to perform tasks. Such formal procedures are based on paper documentation. Examples are procedures for making patients ready for surgery, procedures for performing client personal hygiene in the home health care, and safety procedures on construction sites. Such "health and safety" procedures are well documented and strictly formal. Although common procedures are learnt by hearth, it is sometimes necessary to review the paper documentation.

Our case studies show that in spite of large differences in primary activities, the workers need mechanisms to collaborate and coordinate[11], retrieve information (e.g. formal procedures, standards, background documents and drawings, exchange information, make reports, and order goods and services. This discovery implies the possibility of developing some kind of common toolkit for personnel doing mobile work, independent of their primary activities.

8.2. Other findings

Mobility Context

A common characteristic of all the occupations in this study was that they almost continuously were on the move. E.g. nurses moved from patient to patient in different rooms, home health-care moved from patient to patient in different houses and construction workers moved from section to section. These are classic examples on "remote mobility", that is conventional sense of mobility; individuals who move around different physical locations who require access to patients, colleagues, or information (Luff and Heath 1998). Or as Harrison and Dourish (Harrison and Dourish 1996) would call it, they move from "space" to space. In that sense, they also move from place to place as the same space has different meaning at different times.

Being constantly on the move, will require that mobile ICT must be easily available and wearable. That is, it must be embodied (Mingers 2001) and part of the workers' embodied knowledge and interaction with the world. In our case studies we see this clearly, especially when it comes to the carpenters. In the same way as the hammer, the inch ruler, the knife, the carpenter's pencil, the mobile ICT must become a part of their work wear.

Another notion of Luff and Heath (ibid.) is "micro-mobility". This is related to use of artefacts. In their research, they exemplify this with a medical record, and describe how this medical record is mobilised and manipulated for various purposes "at hand". This is also the case for both Nurses and Home Health-Care. Related to construction site, "micro-mobility" will certainly challenge mobile ICT if we are going to support processes that involve drawings. We have seen that the carpenters discuss what they are going to build over the drawings while concrete workers discuss how to build things. While doing this, they often use their pencils to draw and make notations. It could be relevant to ask whether it is possible to make use of handheld at all in these situations. The drawings are a good example of a fine-grained artefact (Luff and Heath).

ICT literacy

Another common characteristic of all three cases is limited ICT skills among the workers. Usability is a concern, and necessary steps must be taken to develop solutions that are extremely easy to use. (Brodie and

[11] Following Brodie and Perry (Brodie and Perry 2001) we define collaboration as working on a shared task-based goal, whilst co-ordination involves a simpler form of information recall or articulation work (most usually agreeing where to meet, or breaking a task into parts).

Perry 2001) supports this concern, and reports heavily use of mobile phones among blue-collar workers, but also that many of their subjects were extremely resistant to using other forms of technology.

Usability itself is not a guarantee for success. The workers must experience perceived usability. Success is only obtainable if the perceived benefits of using mobile ICT outweigh the resistance against technology.

Experiences with the methods

Two basic methods for studying the nurse's activities were applied: Interviews and studies of descriptions of formalised procedures, and observations coupled with grounded brainstorming sessions to discuss and interpret the observations. It is interesting to note that the interviews and formal procedures were almost only limited to descriptions of primary work activities, while it was only as a result of the observations we became aware of the extent and importance of the secondary work activities.

Rationale for mobile ICT

In all three cases, workers spend significant time on secondary activities. If secondary activities can be done more effectively, workers can spend more time on primary activities. Mobile ICT may reduce time spent on secondary activities and improve quality.

A note of concern

It is important to recognize that mobile ICT only provide a partial solution. All three cases show significant amounts of tacit knowledge and social relations between co-workers.

8.3. Technology and mobile applications

We have so far presented three different cases, and possible application areas. Mobile ICT implies mobile terminals with wireless transfer capability. Currently, three major types of mobile terminals exist: Mobile phones, PDAs (Portable Digital Assistants) and Tablet PCs. Normal laptop PC's are not discussed here.

Mobile phones

State of the art mobile phones include ability to run programs. Three major technologies exist: WAP/WML, J2ME and SmartPhone. All technologies have data entry capabilities, presentation capabilities and a communication protocol stack. All three technologies also support encrypted data transfer between mobile terminal and server hosting information system.

The main difference is programming languages and their functionality.

- WML (Wireless Markup Language) is a script language with a limited set of functions, but support for data entry, client side validation, data transfer and presentation.
- J2ME (Java 2 Mobile Edition) applications are programmed in Java, has more functionality, and runs on a limited Java virtual machine.
- SmartPhone is a Microsoft technology. Programs are currently programmed in C++, but other languages are possible. SmartPhone has rich functionality. By using the .NET compact framework, it is possible to develop applications in Visual Studio .NET.

PDA's

State of the art PDA's has the same capabilities as mobile phones, but have more powerful CPU, larger screen, better graphical interface and stylus based input. Two major technologies exist: Palm and PocketPC.

Again, the main difference is operating system functionality and programming languages.

- Palm is based on the Symbian operating system.
- PocketPC is based on the Windows CE operating system

Tablet PC's

Tablet PC's are a quite new technology. Tablet PC's have large screens with stylus based input. It allows for heavier data entry than PDA's.

	Mobile phones	**Personal Digital Assistants** **Tablet PC's**
TECHNOLOGY		
Output	LCD-displays, small	LCD-displays, from 180x320.
Input	Buttons	Stylus / handwriting / virtual keyboard
Communication	GSM / GPRS / (UMTS)	GSM / GPRS
APPLICATIONS		
Communication and collaboration	Can be used to send predefined messages and simple text messages. Relatively simple e-mail functionality	Can be used to send rich messages. Full e-mail functionality, including handling of different types of attachments.
Knowledge and experience retrieval, storage and transfer.	Limited data entry capabilities. Presentation capabilities is present, but not for larger tables. External or internal camera can be used to transmit medium resolution pictures. Menus can be used for selecting information to be retrieved.	Better data entry possibilities for complex tasks. Presentation capabilities are good, also for tables. Menus can be used for selecting information to be retrieved. Easy to use text fields for search criterions.
Logistics	Menus can be used to order among a fixed number of goods and services.	Order forms may be filled in by user.
Quality assurance	Presentation capabilities are present (structured text, limited graphics). Limited data entry capabilities.	Checklists may be filled in by user.
Coordination of activities and time-handling	Presentation capabilities are present (structured text, limited graphics). Limited data entry capabilities.	Checklists and forms may be filled in by user.
COMPETENCE		
IT skills required	Low	High (training often required)
CONCLUSION		
	Mobile phones have limited functionality, but low user threshold. Widely in use among professionals studied. Low costs.	Current PDA's have wide range of functionality. User training required. High costs.

Table 2 – Mobile ICT

8.4. Framework Evaluation

By applying the framework on three different cases, we certainly did obtain a deeper understanding of different aspects of mobile work.

The development of the framework itself, as well as the actual application of the framework to the three cases, has certainly been a process of maturation. We cannot say that maturation is completed, but we are currently able to do a preliminary evaluation of advantages and disadvantages of the framework.

We learned some important lessons. First, it was very useful to split activities into primary and secondary ones. This helped us to discover an important pattern. In all three cases, we found that mobile ICT was inappropriate to support primary activities. On the contrary, it became evident that mobile ICT could very well support secondary activities. Mobile ICT can improve both efficiency and quality, and the mobile workers could be able to spend more time on primary activities.

This observation could be an important contribution to mobile ICT design and development processes.

Second, we discovered some inherent problems and disadvantages of the framework. The following list presents problems and possible improvements:

We had some difficulties selecting the appropriate level of detail. Should our focus be on a general level, or should we dive into details. We have tried to use examples that capture typical characteristics of the work performed within each case study. At the same time, we are aware of lack of depth concerning knowledge types and related knowledge processes. Therefore, future work should explore how to better integrate knowledge types and processes into both primary and secondary activities.

Although it was generally easy to separate activities into primary and secondary ones, we found some "blurred" activities that were difficult to place in one particular group. One example is when the mobile phone is used to feed elder people. Improvements will be achieved along with training/experience and further work.

We have identified a set of attributes we found particularly relevant to mobile work. There may still be other relevant attributes. Such attributes will probably emerge as the framework is used to analyze more cases.

We mostly focus on activities and how they are performed, and less on the environmental and organizational aspects. Other frameworks or models like Julsrud (Julsrud et al. 2002), Lyytinen and Yoo (Lyytinen and Yoo 2002) and Kristoffersen and Ljungberg (Kristoffersen and Ljungberg 1998) could help to describe such aspects.

Our framework does not have any mechanism for prioritization. This should be considered, if the framework is to be used as part of a development process. One possible starting point could be to look for common support needs for several primary activities in order to prioritise those support activities with largest impact. An alternative is to rank primary activities based on their individual importance. We suggest this as an issue to be addressed in future work.

9. Conclusion

This report has addressed ICT supporting mobile work among non-office workers. To understand and structure mobile work among such workers, we propose a framework focusing on primary and secondary activities. We applied the framework on three different occupations: Nurses working within hospitals, home health care, and construction.

The framework enabled us to uncover similarities and differences between these occupations. The differences relates to what the workers do, and how and where they perform their tasks. Working to help sick patients in clean, tidy and quiet hospitals certainly are conspicuous from working with materials and tools at a construction site where the workers are heavy exposed for dirt, noisy, variation of temperature. In spite of these differences, we witnessed many interesting similarities. First, many primary activities seemed to trig secondary activities. This was independent of the occupations and we found them in every category. Second, we also witnessed many primary activities involving physical or manual work, while secondary activities involved communication, collaboration, reporting and handling papers or documents. Third, there was clearly proven that topics like "health and security" were well documented and strictly formal. Finally, many activities were left to the workers own judgement, but when things are getting complex or problematic, they search for help and advise from members in the team.

We found that mobile ICT has a potential for supporting secondary activities of non-office workers. Based on these findings, we have suggested some possible applications and technologies for such workers.

By applying the framework of mobile work on the three chosen occupations, we found both advantages and disadvantages related to the framework. The most important advantage was the split of activities into primary and secondary activities. During the splitting and when the split of activities were completed, we found the following pattern; - In all cases, we found it hard to see possible mobile ICT supporting primary activities. However, with respect to the secondary activities, it came very evident the possibilities of support of mobile ICT. Based on an assumption that if secondary work activities are suitable for mobile ICT, and if mobile ICT will improve both efficiency and quality, the mobile workers could be able to spend more time on primary activities. In such a case, this framework could contribute in the design and developing process of mobile ICT within mobile work

While applying the framework we discovered some problems and disadvantages with it. A list of lesson learned and possible suggestions of improvements were presented.

10. Future Work

The most interesting issues for further work are to elaborate our distinction between secondary and primary activities, and to test our framework for categorizing and finding of common attributes. So far, the distinction between secondary and primary activity seems useful and makes it easier to find a common ground for cases that are not strictly white-collar. However, we need more empirical work to state the usefulness of the distinction. This should also include empirical data from other mobile, "non-office" occupations. In addition, we should explore and elaborate more on what are the disadvantages when we focusing on the secondary activities and ICT support of these?

In our work, we have also designed a prototype for home health-care personnel. The prototype needs to be tested out in practical work situations. Before testing it, we need to do more work on how to run the test and what we should measure. Setting up an experiment that can provide useful findings is not a small task, and is clearly a topic for further work.

11. References

Agre, Philip E. 2001. Changing place: Contexts of Awareness in Computing. *Human-Computer Interaction* 16 (2):177-192.

Alavi, Maryam, and Dorothy E. Leidner. 2001. Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Issues. *MIS Quarterly* 25 (1):107-136.

Bellotti, Victoria, and Sara Bly. 1996. Walking Away From the Desktop Computer: Distributed Collaboration and Mobility in a Product Design Team. Paper read at Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work, at Boston, Massachusetts, United States.

Bergman, Eric. 2001. *Information Appliances and Beyond: Interaction Design for Consumer Products*, *Interactive Technologies*: Morgan Kaufmann.

Bowden, Sarah. 2004. *A Consultant In Contractors Boots*. ARUP 2003 [cited Feb 2004]. Available from http://www.cite.org.uk/PII/bowden/consultantcontractor.pdf.

———. 2004. *Construction Site Communications*. ARUP 2003b [cited Feb 2004]. Available from http://www.cite.org.uk/PII/bowden/constructionsitecomms.pdf.

Bowden, Sarah, A. Thorpe, and Andrew N. Baldwin. 2003. Usability Testing of Hand held Computing on a Construction Site. Paper read at CIB W78, at Auckland, New Zealand.

Brodie, Jacqueline, and Mark Perry. 2001. Designing for Mobility, Collaboration and Information use by Blue-Collar Workers. *SIGGROUP Bull.* 22 (3):22-27.

Dey, Anind K. 2001. Understanding and Using Context. *Personal and Ubiquitous Computing* 5 (1):4-7.

Fagrell, Henrik, Fredrik Ljungberg, Magnus Bergquist, and Steinar Kristoffersen. 1999. Exploring Support for Knowledge Management in Mobile Work. Paper read at The European Conference on Computer Supported Cooperative Work (ESCW'99), at Copenhagen, Denmark.

Fallman, Daniel. 2003. Enabling Physical Collaboration in Industrial Settings by Designing for Embodied Interaction. Paper read at Proceedings of the Latin American conference on Human-computer interaction, at Rio de Janeiro, Brazil.

Gershman, Anatole V., Joseph F. McCarthy, and Andrew E. Fano. 1999. Situated computing: Bridging the gap between intention and action. Paper read at The Third International Symposium on Wearable Computers, at San Francisco, USA.

Harrison, Steve, and Paul Dourish. 1996. Re-Place-ing Space: The Roles of Place and Space in Collaborative Systems. Paper read at Proceedings of the 1996 ACM Conference on Computer Supported Cooperative Work, at Boston, Massachusetts, United States.

Julsrud, Tom Erik, Birgitte Yttri, Eva Mjøvik, and Petter Nielsen. 2002. Nomadiske brukere. Oslo, Norway: Telenor FoU.

Kakihara, Masao, and Carsten Sørensen. 2001. Expanding the 'mobility' concept. *SIGGROUP Bull.* 22 (3):33-37.

Kristoffersen, Steinar, and Fredrik Ljungberg. 1998. Representing Modalities in Mobile Computing: A Model of IT-use in Mobile Settings. Paper read at Interactive Applications of Mobile Computing (IMC'98), at Rostock, Germany.

Kucza, T. 2001. *Knowledge Management Process Model*: Technical Research Centre of Finland,VTT Publications.

Luff, Paul, and Christian Heath. 1998. Mobility in Collaboration. Paper read at Proceedings of the 1998 ACM conference on Computer supported cooperative work, at Seattle, Washington, United States.

Lyytinen, Kalle, and Youngjin Yoo. 2002. Research Commentary, The Next Wave of Nomadic Computing. *Information Systems Research* 13 (4):377-388.

Mingers, John. 2001. Embodying information systems: The contribution of phenomenology. *Information and Organization* 11 (2):103-128.

Polanyi, Michael. 1966. *The Tacit Dimension*. London, UK: Routledge and Keoan.

Skattør, Bente. 2003. En beskrivelse av to byggplasser Selvaagbygg AS. Confidential Working Paper.

Wiberg, Mikael, and Åke Grönlund. 2000. Exploring mobile CSCW: Five areas of questions for further research. *European Journal of Information System* 4:74-81.