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Nurse Communication Assistance

User-centred Design in Healthcare Context

Master of Science Thesis in the Master Degree Programme, Industrial Design Engineering

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Preface

This report is the final outcome of a master thesis; the final examination for a Master of Science in Industrial Design Engineering at Chalmers University of Technology in Gothenburg, Sweden. It was carried out at the Feature Management department at Ascom Wireless Solutions during spring 2010. I would like to thank everybody that contributed with their time, energy and knowledge, without whom this outcome would have been impossible.

A special thanks goes to my supervisor at Ascom Wireless Solutions: Sara Eggert, who has been a great support during the project, the rest of the interaction design engineers in the Feature Management team: Karin Eklund, Magnus Nilsson and Anders Jutebrant-Ivarsson as well as all other employees at Ascom who have contributed with time and knowledge.

I would also like to thank my supervisor at Chalmers University of Technology: Oskar Rexfelt, who has provided me with great support throughout the whole process, as well as my examiner MariAnne Karlsson.

Last but not least my thanks goes to the nurses that let me take part of their work and fellow students and friends who have contributed in different ways.

Linnea Fogelmark

Gothenburg, July 28. 2010

Abstract

This master thesis was carried out at Ascom Wireless Solutions, a company that markets wireless communication solutions. The aim was to investigate the flow of information around nurses in healthcare processes and to develop a communication solution that is dedicated to its context of use and that fits in the product portfolio of Ascom.

The research question: *How can the information flow be rationalised to give the nurse more time and energy for the patient?* was addressed both from an analytical and a synthetic point of view, as given by the project aim. Due to this, the project was divided into two phases: phase I - use system analysis and phase II - concept development.

In phase I, a field study was carried out in order to map the information flow around nurses. As data collection, nurses at different wards and hospitals in Sweden were shadowed in their daily work, and interviews were made with nurses and their managers. The outcome consisted of a number of focus areas, relevant for the information flow. They dealt with audible information overload, inefficiency in information handling, emotional sensitivity in communication and technical communication tools with lack of adaption to the current situation.

The outcome of phase I set implications on the technical communication tool that was to be developed during phase II. Several iterations within the development phase led to the final concept, called MYco.

MYco is a communication assistant designed according to the principle of calm technology; technology that interacts unobtrusively and natural with the user. It has two modes; one simple mode with intuitive interaction where the basic functions are handled, and one mode with possibilities of more advanced functionality. MYco has a number of sensors, which detects the surrounding circumstances and adapts the modality of call- and alarm signals. By covering the device with the hand it is instantly silenced, allowing the nurse to work uninterrupted. The interface has a high degree of learnability, but a lower degree of guessability to assure a usable product that at the same time protects patient privacy.

Keywords: user-centered design, usability, calm technology, interaction design, design for healthcare, shadowing, communication, information technology, alarm fatigue, patient-centered care

Phase I

Phase II

1. Introduction

This chapter presents the structural framework of the project. The context in focus and the company at which the project was made are introduced in section 1.1. Thereafter is the focused turned towards the scope of the project, with aim, research question, goal, project planning and limitations presented in sections 1.2 - 1.6. Ultimately, section 1.7 defines some terms that are frequently used throughout this report and could be in need of some clarification.

1.1. Background

1.1.1. Communication in Healthcare

Healthcare is a subject under constant discussion in many parts of the society; politicians debate about its structure, hospitals struggle with medical, economical and organisational issues, the private industry tries to turn medical improvements into profit and the public are concerned about getting good care. Historically, the stake holders together have pushed healthcare through constant improvement. Medical breakthroughs, technical innovations as well as organisational improvements are essential parts of the history as well as the future of healthcare.

In recent years, healthcare, as well as many other parts of our society, has turned towards personalisation; building flexible structures that adapt to the individual. Progress in the medical field, has set higher demands on the healthcare staff, requiring more specialisation and wider collaboration networks. In addition, technical innovations have further developed the efficiency and complexity of care.

To meet the increasing complexity, the organisational structure of healthcare must support its staff in providing care in a safe, accurate and efficient way. Communication is one important piece of that puzzle and in rich information environments as hospitals; technology is a key factor in providing the right person with the right information, at the right time.

1.1.2. Ascom Wireless Solutions

Ascom Wireless Solutions, further on referred to as Ascom, develops solutions for wireless internal communication. The products are tailored solutions, aiming for professional markets such as industry, prisons and healthcare.

Ascom Headquarter is situated in Gothenburg in Sweden, including the major part of the R&D. A smaller R&D department is situated in Holland, where some of the products dedicated to the hospital segment are developed. The Ascom solutions and products are sold worldwide, though the strongest markets are Western Europe and USA. There are three types of sales channels:

- **Direct sales channels –** Affiliates, owned by Ascom, which sell Ascom products directly to the customer or through retailers.
- **Indirect sales channels –** Sales channels owned by Ascom Headquarter, with sales departments in several countries.
- **OEM –** Products developed and produced by Ascom, but sold under

brand names owned by other companies.

The direct sales channels are generally more focused on selling whole communication solutions than the indirect, whose main focus is product sales.

The products developed at the R&D departments are generally designed to fit all product segments and an international market. Direct sales channels may then make tailored communication solutions by:

- Combining Ascom products into systems
- Developing customised software applications
- Co-operating with other actors on the market, making joint solutions

In the healthcare segment, Ascom markets solutions for communication through paging, messaging, calling as well as alarming. The product range includes pagers, wireless telephone systems and nurse call (alarm- and call systems for patients and care staff at hospitals).

This thesis is made under the department Feature Management, which main responsibility is to ensure a consequent and user-centred approach of the features in the Ascom product portfolio. Feature Management consists of interaction designers and system engineers.

1.2. Aim

The aim of this master thesis is to investigate the flow of information around nurses in healthcare processes and to develop a communication solution that is dedicated to its context of use and that fits in the product portfolio of Ascom.

1.3. Research Question

The research question to be answered is:

How can the information flow be rationalised to give the nurse more time and energy for the patient?

1.4. Goal

The goal of the project is to develop one or a few concepts of a communication solution dedicated to nurses.

1.5. Project Plan

As the project started, a project plan was set up according to figure 1.1. The project was divided into two main phases:

- Phase I: Use System
- Phase II: Concept Development

These two phases were both further divided into sub-phases:

- **Data Collection** – collect data from relevant sources, including literature, experts and/or user research
- **Analysis** – sort the collected data, analyse findings and draw conclusions
- **Synthesis** – implement gained knowledge into project specific solutions
- **Evaluation** – evaluate and revise implementations
- **Presentation** – document results in visualisations and report

A number of supporting phases, including project planning, literature study and report writing were also included in the project.

At the start-up of the project, Phase I was planned in detail in terms of methodology and timetable. However, as the outcome of Phase I was supposed to set

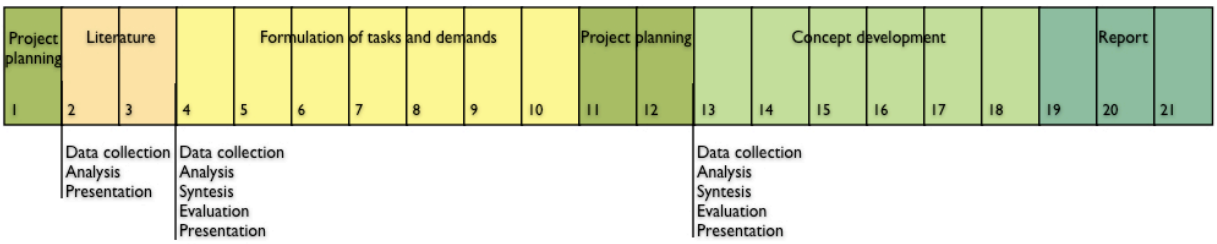


Figure 1.1 Project plan

the prerequisites for the concept development, Phase II was left schematically planned until the second planning phase after finalising Phase I.

The project started off with a broad, exploratory scope, continuously narrowing down towards one concrete product concept.

1.6. Limitations

The healthcare system is a complex structure including a wide range of professions, technology, information channels and work methods. To enable a deep-going study, resulting in a specific concept, the following limitations were made:

- The target group was limited to Swedish healthcare, promoting a more specific solution. Descriptions of professions, organisations and working routines refer to the Swedish system, unless otherwise stated.
- Solely intramural care was studied, limiting the observations to hospitals. This limitation follows the existing division of segments within Ascom, separating hospital care from lighter, long-term care like the elderly care. Further, only inpatient wards were studied, leaving out the outpatient clinics in order to narrow down the target group further.
- Only nurses were included in the observational research, as they were defined as the target group of the intended product. However, in contemporary Swedish healthcare, nurses work side by side with nurse assistant and the latter group could therefore also be considered probable users. In this project, the demands on the product set by nurse assistants were assumed to be covered in those of the nurses.
- Problems indirectly connected nurse's information flow, that is, problems related to the transmitters and receivers around the nurse, were noted and analysed in phase I. However, in phase II they were considered as prerequisites for the concept development. Thus, the final product solution relies on existing surrounding circumstances whichever drawbacks or elements of inefficiency those might imply.

1.7. Definitions

Nurse - in this project defined as a person with a bachelor degree in nursing care as well as an occupational degree as qualified nurse (legitimerad sjuksköterska) , working with intramural care in Sweden.

Nurse assistant – in this project defined as a person working with practical nursing care in Sweden. Nurse assistant (undersköterska) is not a protected title in Sweden, but a common education is three year nursing care at upper secondary school (gymnasium).

Physician – in this project defined as a person with 5,5 year medical studies at university level, completed medical practice work and a medical licensure working with intramural treatments.

Inpatient care – care of patients living at an inpatient ward, having an own bed, getting food from the hospital etcetera

Outpatient care – care of patients coming to outpatient clinics for visits lasting just the length of the treatment, then returning home.

Nurse call system – technical system that allows a patient to contact the nurse, most commonly by pressing a button. The nurse gets alerted of the call through sound and/or light.

Nurse presence system – technical system allowing nurses to state that they are in a certain room, often logging in and out by pressing a button at the entrance of the room. The room is then highlighted with the state “nurse presence” visible for other nurses (and patients).

2. Framework

In this chapter, the theoretical framework for the project is presented. The knowledge was gathered in different stages of the process and is relevant to different phases. The chapter starts with figure 2.1, giving an overview of the content.

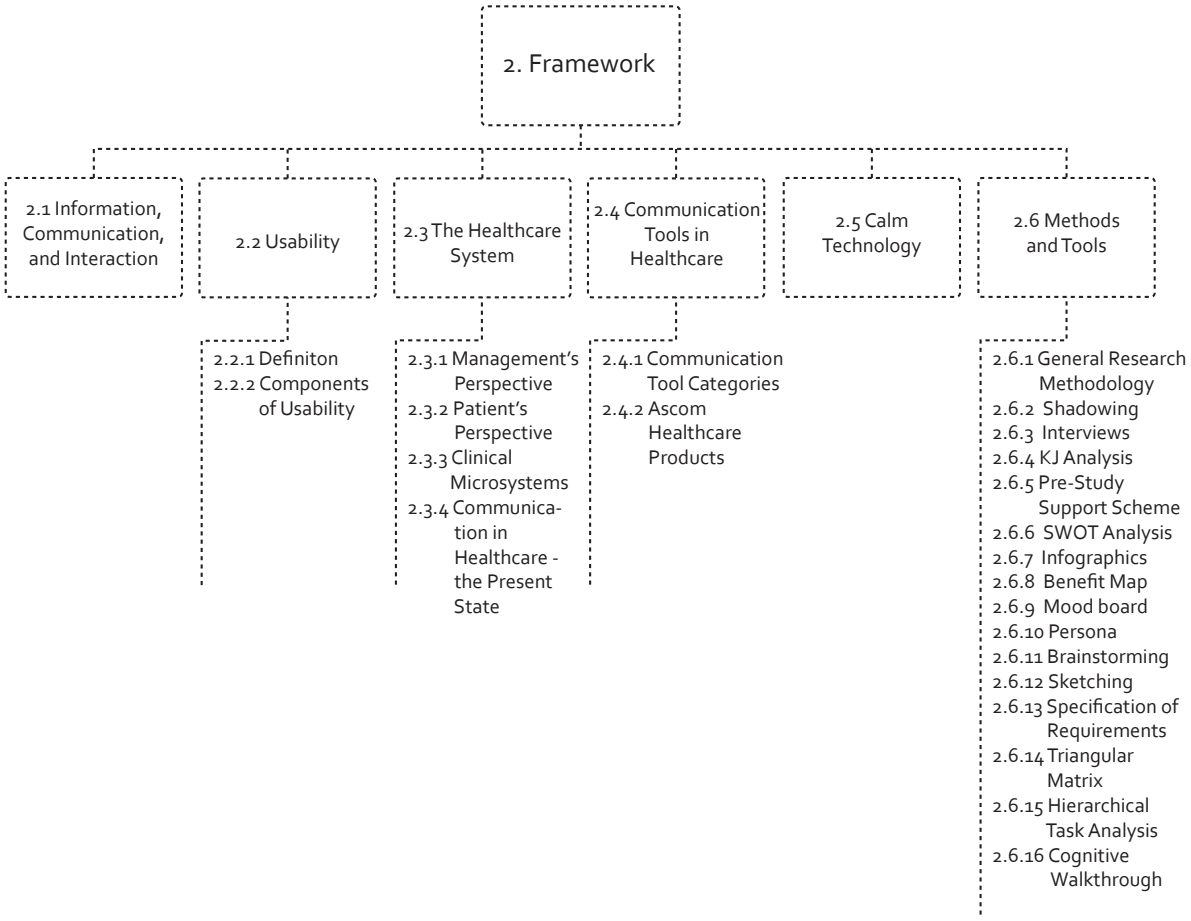


Figure 2.1 Overview of theoretical framework

2.1. Information, Communication and Interaction

The definition of the terms information and communication have long since been objects for debate in different parts of the academic world. Various interpretations exist, however, for this thesis; the definition given by Hård af Segerstad (2002) is chosen and described below.

2.1.1. Information

Information is defined as "every meaning-bearing artefact", artefact being any man-made object or phenomenon. That the artefact is meaning-bearing is substantial; it contains a message that, once transferred to another person could be settled as knowledge.

2.1.2. Communication

Communication is defined as a social process. Hård af Segerstad describes six functions of communication, where the two most important are defined as transmission of information and development of knowledge (the other four being concerned with feelings and values). In this sense, communication can be seen (partly) as the social process that is needed to transmit information. Communication can be both verbal – in words – and non-verbal – body-language, symbols and signs, clothes etcetera – as well as face-to-face and mediated – through another media such as paper, computer or telephone.

2.1.3. Interaction

Interaction is a term that describes the actions that occur between two or more objects: artefacts or humans. In this thesis, however, the term interaction is used as in the science of usability; limited to the actions that occur between human (the user) and machine. Interaction, as well as communication, is a process that transmits information. In the case of interaction though, back and forth between human and machine.

2.2. Usability

2.2.1. Definition

The term usability is often used as a synonym to user-friendliness, meaning how easy it is to use a product. However, according to the strict ISO definition usability is defined as "…the effectiveness, efficiency and satisfaction with which a specified user can achieve specified goals in particular environments" (ISO DIS 9241-11).

In his book An Introduction to Usability, Jordan (2002) gives a further explanation to the three parts of usability. Effectiveness refers to the extent to which a certain goal is achieved. The effectiveness can either be a matter of yes or no, as in succeeding or not, or a percentual extent of how often the user succeeds e.g. the user succeeds with the task 75% of the times. Thus, effectiveness correlates with the functionality of the product, and to what extent it meets the needs set by the user and the tasks to be performed.

Efficiency is the effort needed to complete a certain task. It could be measured in different ways, for example time, frustration and cognitive load. A system that is effective in use, i.e. the user is able to reach its goal, can still be inefficient if the user has to try many times or think a lot to be able to manage the task.

Satisfaction is most the subjective term, measuring how the user experiences the use. To some extent it coincides with effectiveness and efficiency, as a product that works well is more likely to evoke satisfaction in use. However, it is not always true. User satisfaction depends on several factors, such as aesthetical values, the experience of interaction and brand identity values. For many products, especially on the consumer market, satisfaction is maybe the most important usability factor.

Hence, the ISO definition of usability corresponds to the benefit of use, including both user-friendliness and adequacy of the functionality.

Further, the ISO definition of usability states that usability is not a matter of the product only. It depends on the user, the goals that should be achieved and the context of use.

Thus, usability can only be spoken of when looking at a whole use system.

2.2.2. Components of Usability

Since usability happens in the interaction between user and product, it will depend also on the properties of the user. Basic characteristics like age and gender matters, but also the relationship and the experience of the product itself. The last-mentioned, is likely to change rapidly over time, implying that the same product, for the same user may have different levels of usability at different levels of user expertise. This fact was observed by Jordan (2002), who has developed a five-component model of usability, determining the system's usability properties for different levels of user experience. The five components of usability are defined below.

- **Guessability –** the effectiveness, efficiency and satisfaction with which specified users can complete specified tasks with a particular product for the first time.
- **Learnability** – the effectiveness, efficiency and satisfaction with which specified users can achieve a competent level of performance on specified tasks with a product, having already completed those tasks once previously.
- **Experienced User Potential** – the effectiveness, efficiency and satisfaction with which specified experienced users can achieve specified tasks with a particular product.
- **System Potential** – the optimum level of effectiveness, efficiency and satisfaction with which it would be possible to complete specified tasks with a particular product.
- **Re-usability** – the effectiveness, efficiency and satisfaction with which specified users can complete specified tasks with a particular product after a comparatively long period away from these tasks.

2.3. The Healthcare System

2.3.1. Management's Perspective

Modern healthcare is a complex system of different care concepts. Everything from complicated life-saving interventions, to rehabilitation programs, self-care and long term geriatric care is incorporated in the system. Managing healthcare is a well known difficulty world-wide and especially hospitals, are considered to be "extraordinarily complicated organisations" (Glouberman & Mintzberg 2001)

Caring procedures, according to Glouberman and Mintzberg (2001), are though not complicated by themselves, the management difficulties occur not until care is put together in the organisational and hierarchical basic structure of healthcare systems of today. To help understanding this issue, Glouberman and Mintzberg present a framework, see figure 2.2, consisting of four different worlds that coexist in a general hospital.

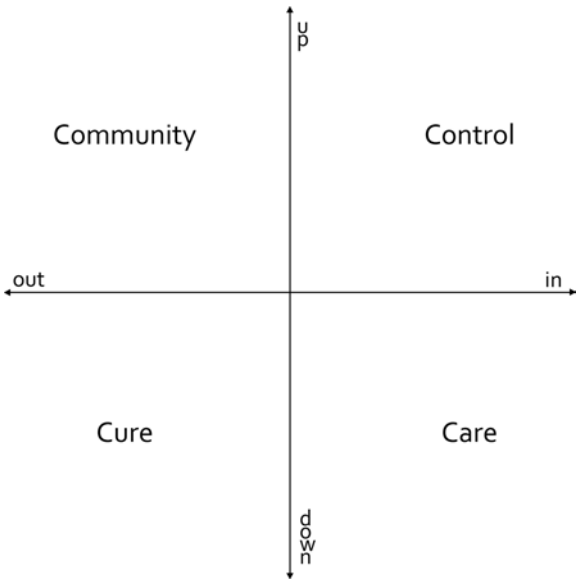


Figure 2.2 The four worlds in hospitals (Glouberman and Mintzberg 2001)

The basis of figure 2.2 are the two lines, whose ends represent four different directions:

- *out* towards the society, independent of the internal hierarchy of the hospital
- *in* towards the hospital's organisation
- *up* involving management and leadership
- *down* close to the core business: the patient

The four quadrants, created of these lines, represents the four worlds described below.

Cure

Cure, the physicians are *down*, towards the patient, but *out*, away from the hospital organisation since they are not under the same hierarchy as the rest of the care personnel. During often scheduled meetings with the patient, physicians intervene by prescribing medicine, performing surgery etcetera. Being the highest expertise in medicine, the physicians have the formal responsibility for the treatment of patients.

Care

Care is managed by the nurses, being responsible for the daily care of the patients. Unlike the physicians, nurses belong to the internal organisational hierarchy and are therefore positioned on the *in*-side of the figure. Self evidentially they are also *down*, close to the patient.

Control

Control consists of the hospital management, the formal authority, administrating formal hierarchies and economical resources. In general, a central task of management structures is controlling processes within their organisations, though in hospitals this is just partly true. The management do have control over the flow of financial resources, but in controlling the actual doings their formal authority is overruled by the medical competence of physicians. As Glouberman and Mintzberg (2001) exemplifies: "When a physician calls and says 'I have a heart, a patient, and an operating room. I know there's no more money in the budget. Should I go ahead?' what manager can say no?"

Community

Community consists of politicians and public structures that ultimately determine the premises of healthcare. As not being directly involved in the care system, they are *out* towards society and *up*, overseeing the activities of the hospital. Naturally, when not being involved in the core business of care and cure, the trustees turn towards the hospital management, Control, with their concerns.

These four worlds all constitute necessary functions for the healthcare system, but their differences in profession, values and influence make them disconnected and separated. Physicians answer for treatments without necessarily being the most well informed of each individual patient, nurses are stuck between the formal authority of hospital management and decisions of responsible physicians, while trustees put pressure on the management, unaware of the limitations of their effort. One question remains unanswered: Where in this picture is the patient and who is looking after the patient's needs?

One central problem is that none of the four worlds described above has access to the general picture about the individual patient's journey through healthcare. The ones being closest are most likely the nurses, but at the same time, they are the ones with the least influence. According to Hellström (2010) Ph. D. in healthcare improvement, current research deals largely with patient-centred care.

2.3.2. Patient's Perspective

The healthcare system can be straightforwardly explained from a patient-centred perspective with a patient leaving his or her home with a given health status at Time 1, entering a journey through the system, consisting of a number of events and finally, exiting at Time 2, with another health status (Nelson et al. 2008). As seen in Figure 2.3 the events that are included in such a journey can be categorised into four major activities:

- **Admit** – the patient is admitted to care either by a scheduled appointment or unexpected incident
- **Assess** – the patient is given a diagnosis and directed to the right type of treatment
- **Care** – the health status of the patient changes, hopefully to the better
- **Discharge** – the patient's treatment is considered ended

However, breaking these activities down into the actual care units a patient passes through, it becomes more complex. Consider as example, the situation below:

Thomas suddenly gets a heavy chest pain. He is picked up by an ambulance and taken in at the emergency ward. He is given the diagnosis myocardial infarction and is sent to a coronary care unit (CCU). Shortly after his arrival, he is sent to the radiology department for a sonography that will help determine the size of the infarction. Back at the CCU again, blood tests are taken regularly to keep track of the condition of the heart muscle. The tests are sent to the lab for analysis. Thomas is in need of by-pass operation, and he is sent to surgery. After that, Thomas stays at the CCU until his condition is stabilised and he is sent to a regular care unit. When Thomas is considered well enough to go home, he is discharged from the hospital and remitted to a rehabilitation program to get back to a normal and healthy life.

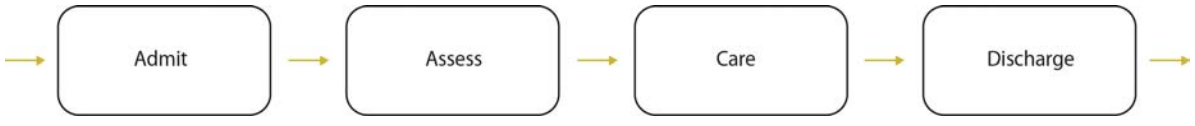


Figure 2.3 The main activities of healthcare (Åberg, 2010)

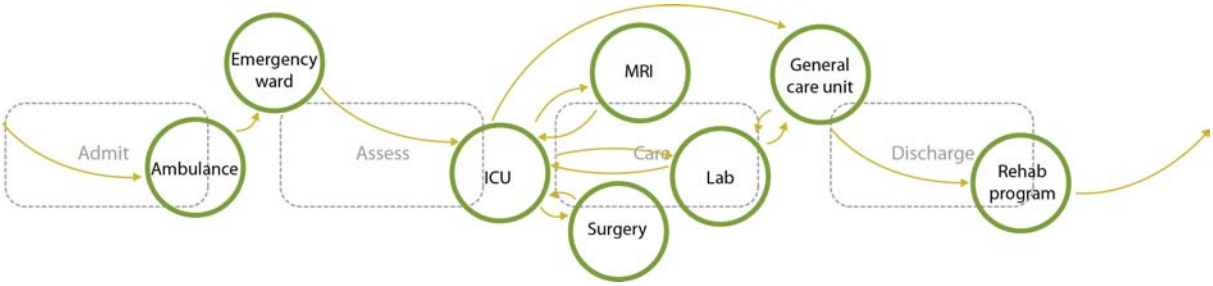


Figure 2.4 A heart patient's journey through healthcare

The journey through care for a heart patient, like Thomas in the example above, is illustrated in figure 2.4. It is by Nelson et al. (2008) referred to as "a patient's unique health system" and portrays healthcare as a series of small units, so-called microsystems (Mohr, Batalden & Barach 2004; Nelson et al. 2002; Nelson et al. 2008), through which patients pass.

According to Nelson et al. (2008) the quality of care is ultimately determined by what happens within and in between these microsystems. Patient treatment is not better, nor worse than what these small units can provide, which is further shown in the hospital quality equation (The Dartmouth Institute 2010). Q stands for quality:

$$Q_{hospital} = Q_{microsystem\ 1} + \ldots + Q_{microsystem\ n}$$

High quality care is provided through microsystems that successfully create the patient's unique health system by "wrapping around the patient's and family's evolving needs and knitting care together to form a seamless health system for this particular patient" (Nelson et al. 2008). In heart patient Thomas' case, this would thus mean that his journey through care would look like in figure 2.5; starting with the ambulance and continuing with a number or microsystems smoothly fitting together, forming Thomas' unique health system.

Looking back at the four ostensibly incompatible worlds of hospital: Cure, Care, Control and Community, the one issue that they all have in common is exactly this: the health of the individual and the population, and each and everyone's unique care, recovery and well-being (Glouberman & Mintzberg 2001).

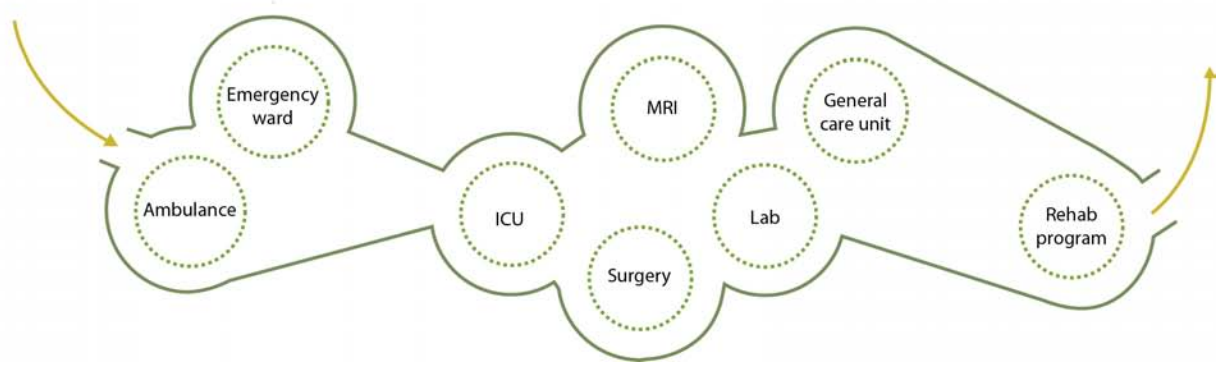


Figure 2.5 A heart patient's unique health system

2.3.3. Clinical Microsystems

One attempt in putting the patient in focus in healthcare management is the microsystem theory, introduced briefly in the previous section. In this section, the theory is discussed more deeply, defining microsystems and discussing the factors that make them successful.

The clinical microsystem is by Mohr, Batalden and Barach (2004) defined as "a group of clinicians and staff working together with a shared clinical purpose to provide care for a population of patients." It is typically geographically limited and specialised in providing a certain type of care.

Even though the microsystem in reality consists of a group of patients being taken care of by a group of staff, as defined above, it can, in its simplest form, be viewed as the caring team around one single patient. Let us return to heart patient Thomas: After being taken in at the hospital's emergency ward, he is sent to the CCU, an intensive care unit specialised on heart diseases. Thomas is now surrounded by the microsystem CCU, which main components are illustrated in figure 2.6. Thomas is taken care of by a group of medical staff, consisting of physicians, nurses, nurse assistants and administrators. Due to his sever illness; Thomas is in need of constant supervision. To their support, the medical team has an extensive amount of technology supervising Thomas' medical condition. The microsystem also includes Thomas' family. They visit him regularly and provide the staff with important information. Within the microsystem there is a constant flow of information, illustrated by the lines in the figure.

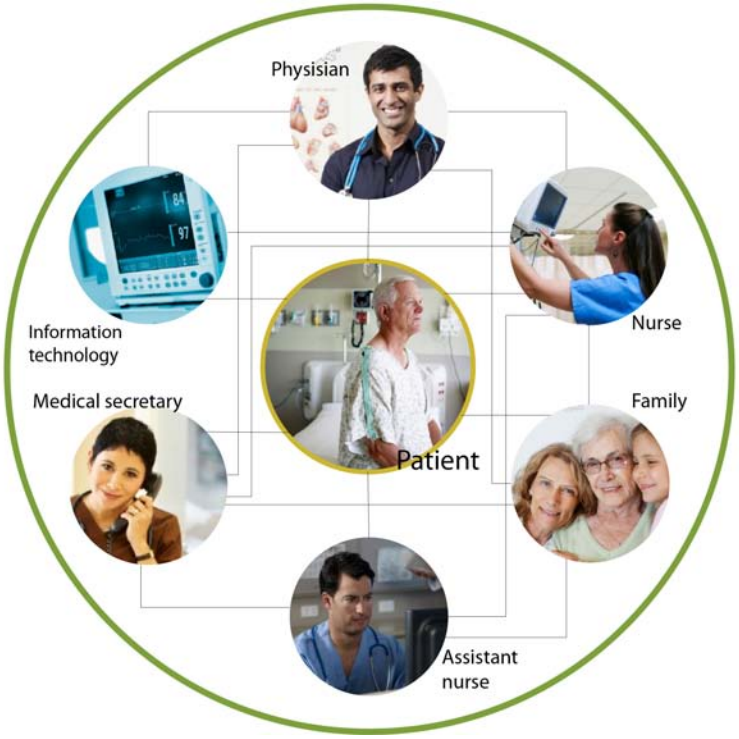


Figure 2.6 Microsystem

Microsystems can be roughly divided into two categories (Åberg, 2010), as in figure 2.7. Some microsystems, so called consumers, are ward units that give nursing care of a group of patients under a short or a prolonged time. The consumer wards are generally specialised in a range of patient groups or diagnosises. The other type of microsystems is called providers due to that they provide the consumer wards with services, for example examining tests or performing x-rays.

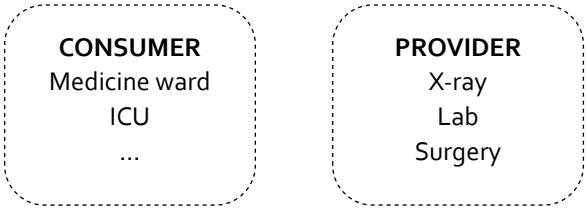


Figure 2.7 Microsystem categories

2.3.3.1. Systems in systems

Clinical Microsystems are embedded in larger systems. Schematically the healthcare system can be viewed as an onion structure, see figure 2.8, with the patient as the kernel. Immediately outside of the patient is the microsystem; which in its turn can be included in a mesosystem. Mesosystems are a collection of microsystems that provides care to the same population of patients, for example heart patients, cancer patients or pregnant women. The whole hospital can be referred to as the macrosystem and it exists within an even larger social structure (Nelson et al. 2008). To provide patient-centred care, the focus must be turned inwards in the structure, a statement that is supported by the hospital quality equation defined in the previous section; the quality of a macrosystem can never be better than the quality of the microsystems of which it is formed (Mohr, Batalden & Barach, 2004).

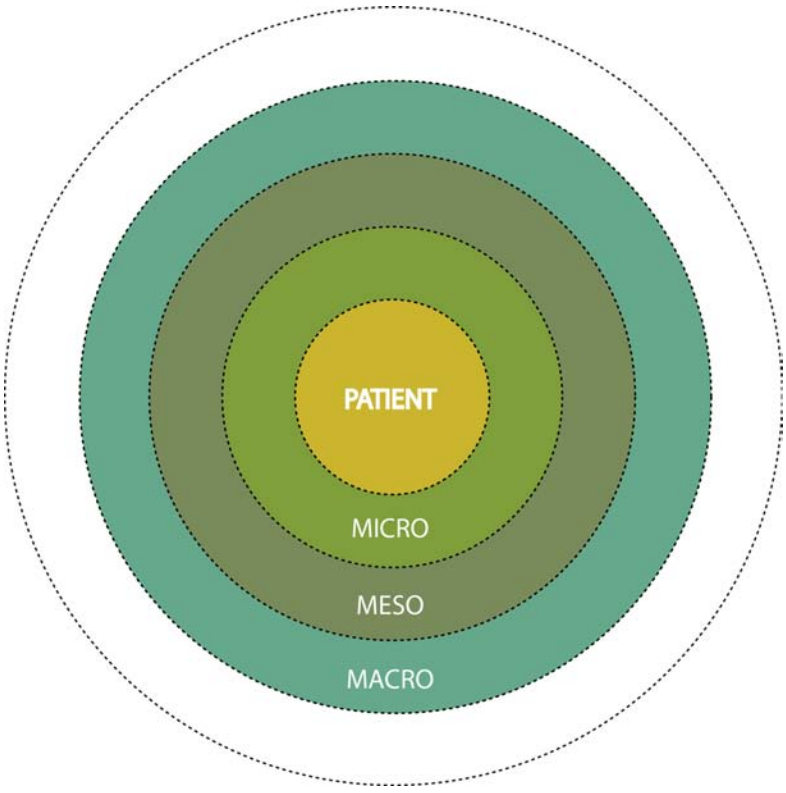


Figure 2.8 Systems in systems

2.3.3.2. Successfactors

What are then the factors that makes microsystem successful components of high quality healthcare?

In current research, taking on the microsystem view of the healthcare structure it is stated that successful microsystems are microsystems that provide effective and safe patient-centred care as well as contribute to seamless individual care for each patient. A number of studies have been made on what factors that characterise successful microsystems. A study by Mohr and Donaldson (cited in Mohr, Batalden & Barach, 2004), investigating high performing clinical microsystems, identified eight dimensions that were related to high quality care, concerning constant improvement, organisational factors et al. One of the eight dimensions was defined as "integration of information and technology into work flows" (Mohr, Batalden & Barach, 2004). In another study, conducted by Nelson et al. (2002), nine so-called success characteristics for clinical microsystems were defined. These were further grouped into four main categories, as seen in figure 2.9, with information and information technology as one of the four.

As a conclusion, information is a key factor to successful care. A rich information environment within and in between microsystems, as well as between microsystem and macrosystem includes (Nelson et al. 2002):

- Support of core competencies and core processes
- The right information at the right time
- Effective communication
- Multiple formal and information channels

In achieving the goals above, information technology is the key. Nelson et al. (2003) introduces "Feed forward and feed back" as a framework for an effective use of information in the core process of delivering care. Feed forward, means collecting and saving data and using it again later in the care process. Effective use of feed forward, that is collecting the right data at the right time, delivering it to the right person in the right situation, is a head mark for successful microsystems. The same is valid for feed back, where information about what happened to a patient is gathered to improve care in the future.

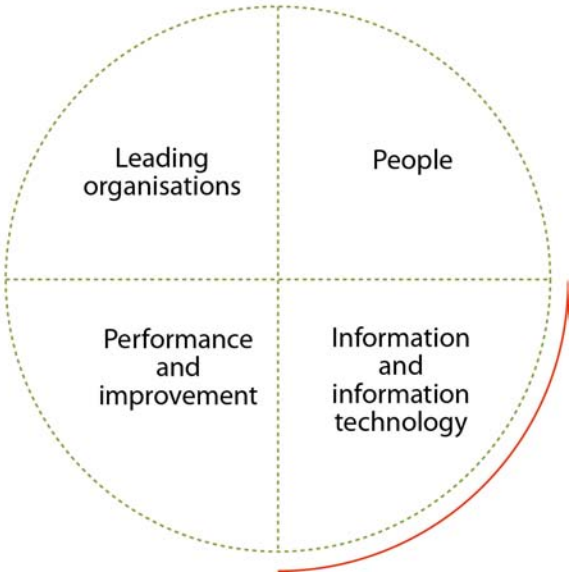


Figure 2.9 Success factors of microsystems

2.3.4. Communication in Healthcare – the Present State

The hospital constitutes an information intensive work place; several different professions collaborate in sometimes critical situations, dealing with life and death of their patients. Continuously increasing medical knowledge, technical innovations and organisation rationalisation are all factors that contribute to the increasing information load for healthcare personnel. As in all contexts, communication is a necessity and a potential factor of improvement, but at the same time it brings on some difficulties. Four topics, relevant for the current state of healthcare in Sweden, are discussed below.

2.3.4.1. Emotion Work

Emotion work is a fundamental part of nursing work, with the aim of creating an empathic and caring atmosphere around the patients (Miller et al. 2008). It is done, not only because of that it is paid for but rather for ideological purposes and it includes skillful, emotional management of the nurse team as well as endurance with patients and suppression of irritation towards physicians. This implies that even if the patients constitute target of the emotional atmosphere, emotion work is present also in nurse-physician and nurse-nurse relationships. Miller et al. (2008) state that nurses "strove to maintain 'a smile on their faces' when dealing with physicians, and displayed politeness rather than authority when supervising subordinates".

Further, Miller et al. suggest nursing work as a framework for understanding the difficulties in inter-professional collaboration that has been identified through several studies (Miller et al. 2008; Glouberman & Mintzberg 2001).

2.3.4.2. Alarm Fatigue

Information technology is widely used in supervision of patients' health status. Monitoring heart rate, breathing, oxygen saturation etcetera is essential for seriously ill patients. Mostly, these monitors have audible alarms, alerting the nurse when a serious problem occurs. However, such supervising technology is "only as reliable as the clinicians who use it" (Creighton, Graham & Cvach 2010)

A study of Creighton, Graham and Cvach (2010) at a medical progressive care unit with 15 patients showed an average of 942 alarms per day, meaning one alarm every 92 seconds. Further, research has shown that an overwhelming majority of all audible alarms are false-positive, with less then 1% of all alarms resulting in change in management of the patient. It is evident that this represents a considerable risk of alarm fatigue, possibly leading to alarms being unobserved, ignored or even disabled by the healthcare personnel.

2.3.4.3. Checking Vital Parameters

That vital parameters such as blood pressure, saturation, pulse and temperature are of significance when determining the changes in health status is a part of the common medical knowledge.

In a project concerning quality improvement in healthcare Dickmark et al. (2010) have studied the process of taking care of in-patients with unexpectedly worsening condition. In a literature review they state that several studies have been made on the correlation between changes in the vital parameters and worsening condition. One example is an Australian

study (Hillman, Bristow, Chey, Daffurn, Jaques, & Norman, 2002 cited in Dickmark et al., 2010) showing that more than 60% of the patients transferred to ICU due to worsening conditions showed abnormal vital parameters at least eight hours before the transfer. Further, several studies shows the significance of nurses detecting a negative pattern in vital parameters and involving a physician.

In their study at a hospital in Sweden, Dickmark et al. (2010) identified a lack of synoptic documentation of vital parameters as well as lacking habits of contacting physicians in case worsening parameters.

As for the nurses' unwillingness of contacting physicians a negative attitude between the two professions was one part of the explanation. The lack of overview over parameter documentation was explained by the use of several coexisting and unstructured places to record patient data.

2.3.4.4. Patient Focused Care

Patient focused care (Edquist & Engvall Vogel 2006) is a working method first introduced in the USA, late 1980. It was brought to Sweden, adjusted and introduced at hospitals around 2000. Patient focused care includes is a holistic method based on findings saying that patients who feel seen and attended to by the nurse, recover faster and better. The exact content may vary according to hospital and needs but some central components are presented below:

- Organisational structures
  - nursing teams (or nursing pairs) consisting of both nurses and nurse assistants caring for a small group of patients
  - co-ordinator responsible for answering and redirecting incoming calls, overlook patient flow etcetera
- Philosophical structures
  - focus general view of man and treatment of patients
  - deepened professional knowledge
- Architectural structures
  - hospital buildings planned to gather patients with similar needs minimising the need of patient translocation
  - open nurse stations close to patient rooms, minimising the distance between nurse and patient
- Technical structures
  - wireless technical equipment rationalising workflows
  - individual wireless telephones allowing nurses to answer redirected calls as they are working

2.4. Communication Tools in Healthcare

2.4.1. Communication Tool Categories

2.4.1.1. Nurse call

Nurse call is a system with which the patient can call for attention from the nurse, by pressing a call button. The call reaches the nurse either as a common audible signal heard within the whole ward, or as a personal signal from a handset that (s)he carries with her. The nurse can locate the sender of the call either by the room

number being shown at a display in the corridor, by a light being lit outside the room or by the room number being displayed at the handset.

The market-leading producer of nurse call systems in Sweden is the Swedish company BEST (figure 2.10 and 2.11), though Ascom is one competitor (figure 2.12).

2.4.1.2. Physiological Monitor

Seriously ill patients may need constant monitoring of values such as heart rate, blood oxygen saturation, respiration rate, temperature etcetera. A physiological monitor is a medicine technical device that, when connected to the patient, may monitor these values and notify clinicians of critical situations by automatic alarms. In figure 2.13 an ECG monitor, a type of physiological monitor, is shown. Normally physiological monitors send their values wireless by telemetry to a patient monitor (figure 2.14), displaying values, curves and alarms remotely at for instance the nurse station. The physiological monitor may also send telemetric alarms to handsets.

2.4.1.3. Pager

Paging is a common communication mediator in healthcare, alerting the clinicians about alarms or calls by audible and vibration signals. Pagers can be connected to several systems; most commonly being nurse call systems where the nurse is notified about a patient call, physiological monitors that send automatic alarms through the pager and the normal telephone system where clinicians can be asked to call a certain telephone number.

Ascom is the market-leading producer of pagers for healthcare in Sweden (figure 2.15 and 2.16).

2.4.1.4. Telephone

Telephones are used as communication tools in every level of the healthcare system; within the microsystem, out towards the macrosystem as well as with authorities and relatives outside of the hospital. Some kind of telephone system is a necessity at all

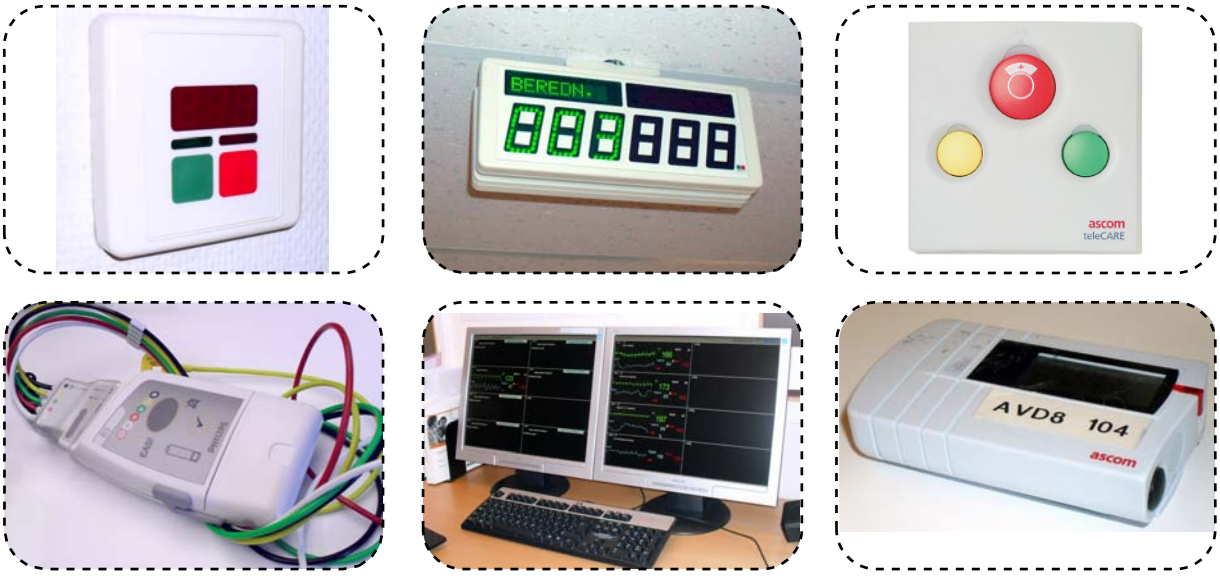


Figure 2.10 BEST nurse call, **Figure 2.11** BEST display, **Figure 2.12** Ascom nurse call, **Figure 2.13** ECG monitor,**Figure 2.14** Patient monitors, **Figure 2.15** Ascom pager

wards, but type, brand and way of use may vary (figure 2.17 and 2.18). At some wards, a co-ordinator works office hours with answering and directing calls to the right nurse, at some, the nurses answers incoming calls directly. In some cases nurses carry wireless handsets with them in their work, in others stationary telephones are situated at the nurse station.

2.4.1.5. Computer

Computers are used by nurses for several purposes. Medical records are kept in computers where the health status of each patient is daily noted. The medical record is also used for checking medical ordinations when distributing medicine. Stationary computers or laptops are therefore common in medication rooms or at medication trolleys (see figure 2.19)

Correspondences such as e-mails, test answers and softwares for shared information are also common computer related tasks.

2.4.1.6. Formularies

Formularies are used for many different purposes, such as handing over information when a patient changes microsystem, storing vital parameters or as checklists for routine procedures. Figure 2.20 shows a formulary for noting vital parameters such as pulse, temperature, blood sugar and weight of each patient at the ward.

2.4.1.7. To-do list

A common method for keeping track patients and tasks is to write a to-do list. The nurse writes down relevant information from the medical record for each patient, along with certain treatments that should be performed during the shift. The information written, and the way of writing it down differs between nurses and over time, as they develop their personal working method and routines. Figure 2.21 shows an example of such a to-do lists, with codes in text, colours and signs developed and fully understood by that particular nurse only.

Figure 2.16 Ascom pagersl, **Figure 2.17** Ascom telephone, **Figure 2.18** Siemens telephone, **Figure 2.19** Lap top on medicine trolley,**Figure 2.20** Formulary , **Figure 2.21** To-do list

2.4.2. Ascom Healthcare Products

In this section the brand identity of Ascom products in general, and Ascom products aiming for the healthcare segments in particular, is analysed. The different products that are marketed towards hospitals within and outside of Sweden are presented in detail.

2.4.2.1. Brand Identity

Ascom has four brand values:

- Ambition
- Talent
- Responsibility
- Competence

Together, they express a will to create high-performing, professional solutions in which the costumer trusts to put responsibility for critical information flows. Further, seven product values found a base for design and development:

- Simplicity
- Ease of use
- Endurance
- Competence
- Grace
- Trustworthiness

These values further elaborate how the brand values are concretised within Ascom products. Here as well, the emphasis lies on products in which the costumer put trust and security.

Figure 2.22 Contemporary Ascom form language

2.4.2.2. Handsets

Ascom offers handsets communicating via voice, messaging, paging and alarming. Figure 2.22 presents the four contemporary products sold under the brand Ascom. Typical form elements are pointed out, showing a uniform product design with rounded shapes, curved lines and a white-blue colour range as brand characteristics.

Both telephones and pagers are marketed towards the hospital segment, with the telephone d62 and pager a71 as lead products.

2.4.2.3. TeleCARE

TeleCARE is a series of products aiming for the hospital- and elderly care segments only; including nurse call, nurse presence and presence displays. TeleCARE is developed in the Dutch R&D department and includes patient handsets for nurse call, radio- and light control (figure 2.23) and wall mounted monitors with nurse presence, nurse call and presence displays.

The visual identity of TeleCARE differs from the handsets with its warm beige colour and bright, round buttons.

Figure 2.23 Ascom TeleCARE patient handsets

2.5. Calm Technology

"The most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it". The quote is from Mark Weiser, chief scientist at Xerox PARC in the nineties (Vasilakos & Pedrycz 2006) and shows the essence of what he believed would be central in technology research and innovations "in a more humanly empowered twenty-first century" (Weiser & Seely Brown 1995).

Weiser is the founder of the term calm technology, by himself defined as "that which informs but doesn't demand our focus or attention" (Weiser & Seely Brown 1995). He spent his scientific career exploring the term and its characteristics and in an article from 1995, Designing Calm Technology he and his colleague John Seely Brown stated that their thoughts were "still incomplete and perhaps even a bit confused". Nevertheless, they had identified three signs of calm technology: The first was that calm technology may step back into the peripheral of our cognition, as being something that we are attuned to, but not have our attention on. He made the comparison of car driving, where the driver has its attention on the road and perhaps the radio, but not the sound of the engine. However, if it would start to sound strange, it would immediately come to the centre of the driver's attention. Weiser and Seely Brown, claim that technology that can move back and forth from the peripheral to the centre of attention is calm, because of that we are ensured of that whenever it is needed we can move it into the centre.

Secondly, calm technology increases our peripheral reach as brings more details into the peripherals. Being informed without having to take the information source into the centre of attention is encalming as we

can stay attuned and focused on more sources to a lower cognitive price.

The third sign of calm technology is referred to as locatedness. Calm technology provides us with a context and an idea of hour own location in relation to others. As for example, a streak of light under an office door may tell the office worker on overtime that he is not the only one left in the building.

Ambient intelligence and ubiquitous computing are two other terms that are similar to calm technology.

2.6. Methods and Tools

2.6.1. General Research Methodology

Design engineering is a typically multi-disciplinary field. It has its basis in engineering science, with a work method consisting of both analysis and synthesis. In contrast to more theoretical sciences, the results from the analysis are not the aim itself, but constitute a knowledge base for the synthesis.

In user centred design engineering, the take-off point is the use situation consisting of the task, the user and its context. To generate requirements for an intended product, the knowledge is therefore collected in the context of use, with an – for the situation – appropriate methodology. Typically, design engineering, in its analysis phase, borrows research methods from other fields according to the type of the project.

In this project, the analysis was influenced by ethnography, a qualitative research method commonly used in social science. The focus of ethnography is the researchers first hand observations of a culture (Czarniawska 2007; Schultze 2000). The culture may be of any kind; a geographically limited society, a social group or a profession et al (Czarniawska 2007; Quinlan 2008; Schultze 2000) and data collection methods include first hand observations, interviews and focus groups (Quinlan 2008). Typically, the ethnographer does not seek to prove a hypothesis, but to open-ended and unprejudiced learn about the foreign culture. Thus, they let the findings of the ongoing research determine the direction of that to come (Czarniawska 2007).

2.6.2. Shadowing

Shadowing is an observation method that closely engages the researcher with the subject and its context. The metaphor of shadowing, deriving from detective stories, is well describing the actual case; like a detective the researcher is following the subject, noticing his or her ways, encounters, sayings and doings. The most obvious difference however, is that the subject is well aware of the presence of the researcher and thus might even be able to explain upcoming situations and events for his or her shadow (Buur & Ylirisku 2007).

Shadowing is used as a data collection method in several research domains, with the purpose of gaining insight and understanding a foreign culture (Czarniawska 2007; Quinlan 2008). As an observation method, it sorts under the category *direct observation*; where the subject is aware of being observed, and further under the subcategory *non-participant observation* (Czarniawska 2007). The non-participation of the shadow should however, not be interpreted too strictly. As Salari (1999) writes: "the key

output is the capture of naturalistic observations and events" and that might require lending a hand or chit-chatting during lunch in order to create a relaxed relation between shadow and shadowed. Further, shadowing, in contrast to stationary observations, is a method where one subject is chosen and followed and the studied culture will be seen from the standpoint of an individual person (Quinlan 2008). Figure 2.24 shows a schematic overview of the categorisation of shadowing.

The advantage of shadowing, compared to data collection through formal papers or even interviews, is according to Sclavi (cited in Czarniawska 2007) "to learn what *is* going on, rather than what *should* be going on".

When shadowing, the shadow follows its subject during a prolonged time. Literature describes shadowing sessions lasting from hours up to some years, with the researcher shadowing the subject in a chosen context being either the workplace, public places, at home or even everywhere, day and night (Czarniawska 2007; Quinlan 2008).

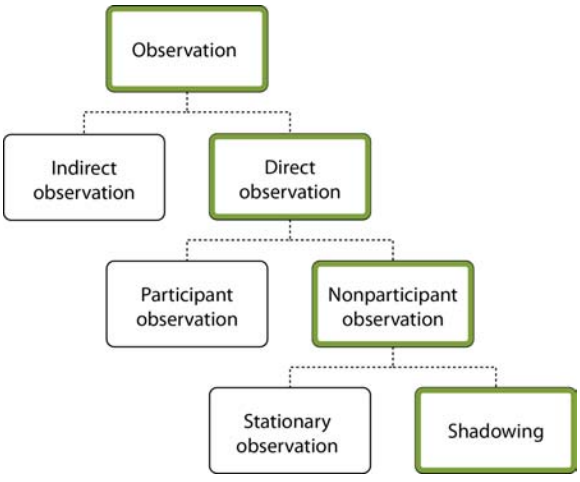


Figure 2.24 Categorisation of observational research

The main activity for the shadow is to observe; that is, watching the subject performing its duties, overhearing telephone calls and meetings, translocating together etcetera. When possibility is given, the subject may be asked to comment on his or her actions; giving their explanations, interpretations and reflections (Quinlan 2008). According to general ethnographic research approach, the observations may be more general in the beginning of the field study, being narrowed down as the field study continues and the big picture is caught (Pilhammar Andersson 1996).

Discretion is a key word in shadowing, and in order to be as invisible as possible, the researcher should seek to blend in, adapting to common manners and looks, as well as keeping a low profile in conversations and other social contexts. When it comes to observations in healthcare, the researcher could seek invisibility wearing a medical uniform without name-tag or a doctor's coat loosely hanging over civil clothes. This, in order to blend in among the clinicians but without risking to be called for help by patients or staff when they are in need of help.

Another important issue when it comes to observations in healthcare environment is to be well aware of patient privacy issues and let the shadowed nurse have the ultimate power to refuse the shadow to attend certain events.

There are several ways of documenting data during observations. When choosing method, a trade-off must be made between the accuracy of documenting the scene picture and sound; and the obtrusiveness of writing discrete field notes. Especially in healthcare context, privacy issues might suggest written notes as the primary

documentation method. Pilhammar Andersson (1996) presents a list of information that should be included in field notes from observations in healthcare:

- Where the observation took place
- When the observation took place
- Which activity that took place
- What was said
- What was done
- Atmosphere, rhythm and tempo

In certain delicate situations in their shadowing, both Quinlan (2008) and Schultze (2000) used so called head notes; they wrote a few key words or nothing at all during the actual events, filling it in with more short notes in a coffee- or washroom break shortly after and writing a coherent story at the end of the day.

2.6.3. Interviews

Interviewing users (Jordan 2002) is a commonly used method to investigate user needs. Interviews can be made either individually or in groups of several interviewees discussing the topic among them. The type of interview method can be divided into three categories:

- **Structured interview –** the interviewee(s) respond to specific questions by choosing from a set of predefined answers e.g. a scale or a number of factors.
- **Semi-structured interview –** the interviewee(s) respond freely to a number of questions. The interviewer might deepen the discussion on a certain topic with follow-up questions as the interview proceeds.
- **Unstructured interview –** the interviewer and interviewee(s) discuss the topic freely without predefined questions.

Whichever method is chosen, the interviewer should have in mind start the interview with questions concerning facts or circumstances that are easy for the interviewee to recall and give an account for. Once the interviewee is warmed up, it becomes easier to reflect on deeper and more complex questions regarding e.g. opinions, needs and wishes.

2.6.4. KJ Analysis

KJ Analysis (Straker 1995) is a tool for structuring data, commonly used as a first step of the analysis in observational research. After observations, interviews etcetera gathered data of all kinds are written down on cards or post-its. The notes may be facts, observed problems, quotes, personal reflections or similar. Once everything is written down, the cards are put out on a large space, on be one, with cards concerning the same area close to each other. As the cards are put out a structure with categories and possible subcategories is built up that will help the researcher get an overview of the collected data and point out targets for the continued analysis.

2.6.5. Pre-study Support Scheme

The pre-study support scheme (Rexfelt 2010) is used in order to further analyse an identified problem. The questions in figure 2.25 support the researcher to asses qualitative, quantitative and time aspects on the problem, deepening and verifying the understanding of the problem.

2.6.6. SWOT Analysis

A SWOT analysis (Houben, Lenie & Vanhoof , 1999) is made in order to

determine the competitive position of an enterprise; being an organisation, a project or a product. Advantages and disadvantages in order to reach a specified goal are mapped to constitute basis for strategic actions.

A SWOT analysis is initialised by setting a goal or a competitive objective as focus for the analysis. Positive and negative factors within four categories are identified, related to the goal:

- **Strengths** – internal positive attributes owned
- **Weaknesses** – internal factors that constitute barriers to obtain the goal
- **Opportunities** – external positive factors, being the reason for the enterprise
- **Threats** – external factors that are uncontrollable and constitute risks

2.6.7. Infographics

Infographics (Klanten et al. 2008) is a way of visually representing information and knowledge by graphical illustrations. It is a powerful tool to turn complex and multidimensional data into an understandable whole. Typically, infographics provide the viewer with an instant overview of the presented data as well as let viewer deepen if wanted. There is no singular way of producing infographics, it has to be made through careful distribution of information, creative thinking and consideration of cognitive aspects.

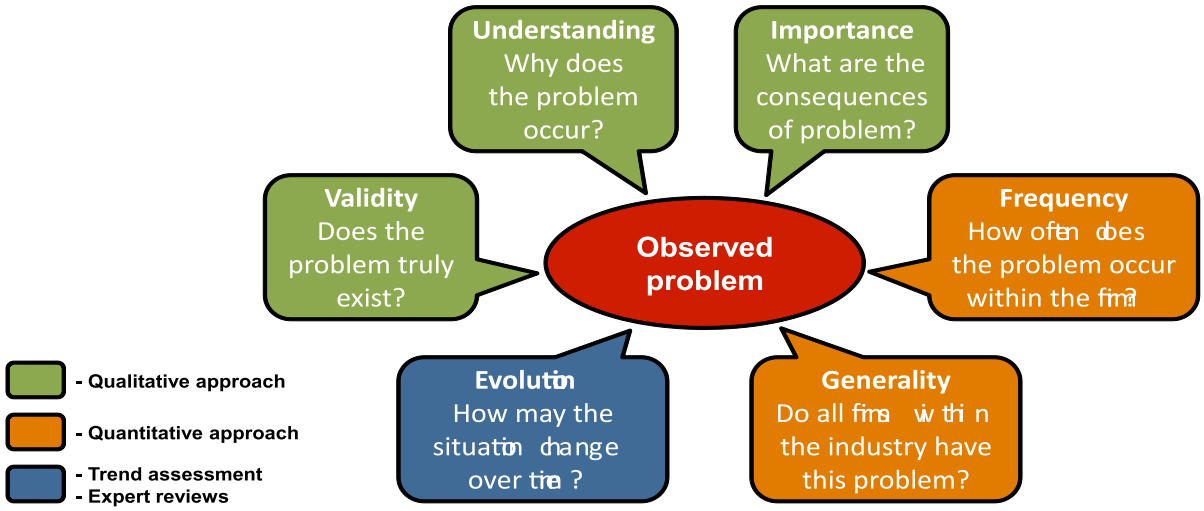


Figure 2.25 Prestudy Support Sceme (Rexfelt 2010)

2.6.8. Benefit Map

A benefit map (effektkarta) is presented by IT consultants and usability experts Ottersten and Balic (2006) as a structured method of mapping users and their aims with using a certain system. A benefit map can be used

- to give a foundation for product development
- to problem shoot and give structure for a project or an investment that is in someway malfunctioning
- as a part in benefit steering, a way of managing IT projects with the users' benefits in focus

Ottersten and Balic state that if the users' goals are clearly mapped in the early stages of the development and kept in mind through the whole process, the final solution will have a higher degree of satisfaction, efficiency and profitability. Thus, the first step of a benefit map is, as seen in figure 2.26, defining the aim of the intended product or system and a number of measurable goals that will later be used as evaluation points. Users that in someway contribute to achieve this aim are then pinned down, together with a weighted rate of how central they are in relation to the stated aim. For each user group, use goals are then defined. Use goals are needs and wishes that the particular group has for achieving the aim and are divided into three categories:

- **Must** – externally set musts, that the user cannot influence, e.g. regulations or technical prerequisites
- **Need** – needs that the user has in order to be able to reach the aim
- **Want** – wishes that make the user has in order to get satisfaction in use.

The last step in a benefit map is to set actions to each use goal, that is suggesting possible solutions within the system, satisfy the demands set by the use goals.

2.6.9. Mood board

A mood board (Baxter, 1995) is a collage of pictures put together to communicate a similar set of sentiments, feelings or emotions that the future product is intended to. A mood board with carefully

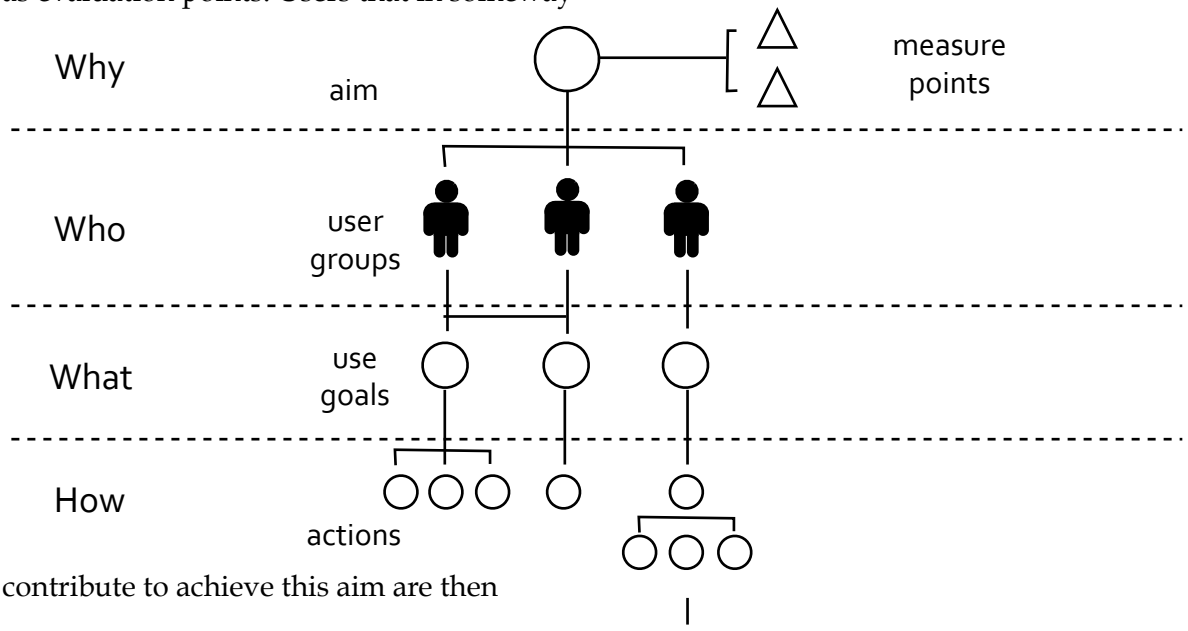


Figure 2.26 Benefit map (Ottersten and Balic 2006)

chosen pictures can act as inspiration source and guiding principle through the whole product design phase; from idea generation to detailed development.

2.6.10.Persona

A persona (i~design 2007, Pruitt & Adlin 2006) is a fictive person, created to constitute focus for the design process. The aim of a persona is to avoid the well-known fact: "designing for everyone is designing for none". It is suggested that it is easier and more effective to design for one specific person, than to aim at a whole user group. If the persona is well thought through, the design intended for this single person will be applicable for the whole user group.

The first step in creating a persona is to get a good knowledge about the user group. Characteristics that are typical for that group are then put together into one realistic person with a name, age, possible profession as well as interests and opinions.

2.6.10.1.Extreme persona

Although a persona could is the typical user for a certain product and that product will be designed specially for that person, the opposite is also valid: the persona is designed specially for the intended product. The fact that persona and product are designed for each other constitutes a risk that some untypical aspects of the design will not be revealed. One way of capturing these peripheral factors is to create extreme personas (Djajadiningrat, Gaver & Frens, 2000).

An extreme persona is persona with untypical characteristics, in relation to the intended product. The extreme persona might dislike the use situation, intentionally misuse it or have other extreme characteristics and needs. Designing for an extreme persona highlights these untypical aspects and might result in innovative "out of the box" solutions.

2.6.11.Brainstorming

Brainstorming (Michanek & Breiler, 2007) is an idea generation method committed in a group of people. It can be used as one of the first steps in a concept development to explore the range of possible solutions for a certain issue. The brainstorming group can be the project team, a group of designers or users. It is not necessary that the participants have a deep knowledge about the focus area on forehand; a couple of fresh eyes are not limited by knowledge of problem areas and previous solutions.

A successful brainstorming has an open, broadminded atmosphere as seedbed for creative thinking and innovative ideas. There are several ways of creating such an atmosphere, below some general guidelines are stated

- Do not criticise! No ideas are bad ideas. Do not focus on the drawbacks of an idea, but on the positive aspects, letting them inspire further ideas. A negative, criticising atmosphere might suppress creativity.
- Care for the group dynamics! Put together a composition of people, equal in hierarchy and expertise. Do not let strong individuals take over and turn negative minds positive.
- Set a structure! Plan one or a few structured methods for idea generation throughout the session, set probes as inspirational inputs and provide the participants with satisfying accessories such as coloured pencils, big papers and something to eat and drink.

A facilitator, moderating the session is a good idea when it comes to seeing to that the brainstorming atmosphere is kept.

2.6.12.Sketching

Sketching is not just a way to visualise ideas and concepts, but also a way to actually explore and elaborate a design. Through rough, fast sketches ideas become explicit and elicit further development as well as highlight possible problem areas.

Sketching could also be done in three dimensions, through rough sketch models made with paper, clay or whatever objects that are at hand. Through 3D sketching shapes easier become crystallised as they can be viewed from all possible angles and the risk of getting stuck in a design that only works from the exact angle from which it was drawn on the paper, eliminated. (Division of Design and Human Factors, 2005)

2.6.13.Specification of Requirements

Specifications of requirements are widely used in all sorts of development and may handle all sorts of demands on products or systems: functional, technical, economical, commercial etcetera. In his book An Introduction to Usability, Jordan (2002) introduces the term usability specification, as a list of demands that ensure a desired level of usability in a product. This is an example of a partial requirement specification, covering a certain aspect of product characteristics only. A similar approach was used in this project. A list of demands covering solely aspects concerning user interaction was made, referred to as a interaction specification.

2.6.14.Triangular Matrix

A triangular matrix (Division of Design and Human Factors, 2005) is used to rate demands, by comparing them in pairs. A rating by a triangular matrix gives a rather clear picture or the relative importance among the demands for a product.

The execution of a triangular matrix can be made either by the development team or with the involvement of users. The demands a written in the columns and rows of a matrix and are then compared two and two, the most important demand of each comparison being written down in the corresponding square. When all of the demands have been compared, that is half of the matrix has been filled in, a ranking of demands can be done simply by counting how many times each and everyone is present in the squares of the matrix.

2.6.15.Hierarchical Task Analysis

Hierarchical Task Analysis (HTA) is made in order to evaluate the functions of a technical system, by breaking it down into its components. Initially a main task is defined, either for the whole system or for a limited part. The task is divided into sub-tasks, which are further divided until the point where the main task is fully divided into its included single actions.

HTA makes it possible to visualise the complexity of a certain task, as well as to show possible inconsistencies in handling procedures. Due to its structured way of viewing a task, it also forms an excellent basis for further evaluation methods. (Ainsworth, 2004)

2.6.16.Cognitive Walkthrough

Cognitive walkthrough (CW) is a method for expert usability evaluation with the aim

of predicting possible usability problems. It is performed by a usability expert, with deep understanding of the product for evaluation, the context of use and the user. A CW is preferably done on the basis of an HTA, analysing every action on the lowest level of the HTA. Taking on the role of a typical user, the evaluator predicts whether the action is motivated, noticeable, understandable and gives adequate feedback. (Jordan, 2002)

Phase I

Use System Analysis

In phase I of the project the use system was studied through observational research. Execution and findings will be presented in this part of the report.

3. Use System Analysis

This chapter includes the process of the use system analysis. In section 3.1, the way of the execution is described. Section 3.2 presents the interim results leading up to the final outcome of the analysis.

3.1. Execution

3.1.1. Data Collection

A literature study was made in order to obtain a theoretical framework for the project. Literature regarding the healthcare system and its management, as well as methodology needed for the observational research was studied. In connection with the literature study, informal interviews were carried out with employees from various divisions at Ascom, as well as with a researcher in healthcare improvement at Chalmers University of Technology. Relevant findings from the literature study can be found in chapter 2 Framework.

The use system was studied through observational research with an ethnographical approach, at six different wards at five hospitals in southern Sweden. The total content of the field study is listed below:

- One interview with management on mesosystem level
- Four observations at four wards at four different hospitals
- Three group interviews at three wards at three different hospital
- Two individual interviews at two different wards at one hospital

An initial non-structured interview was held with two managers in order to understand organisational structures and directional visions and tactics. The aim was to determine how the theoretical approaches studied during the literature research correspond to the reality of hospital management. Of the two managers, one was on microsystem level and one on mesosystem level.

The observations were carried out as four sessions where a nurse was shadowed in her work. The sessions lasted for one or two workdays, covering both morning- and afternoon shifts, as well as weekday and weekend work. No observations were though made during night shifts. During the observations, the nurse was followed wherever she went, with the observer taking field notes of her actions, communication and surroundings. After each shadowing session, the field notes were written out and elaborated further. A formulary was filled in with objective facts such as the number and type of patients, medical technology and staff.

At three of the four observation sites, semi-structured group interviews were carried out with nurses and nurse assistants in groups of two to seven. The interviews were spontaneously introduced at suitable moments such as lunch- or coffee breaks and the interviewees were simply the nurses gathered at the actual place and time. Six questions (see appendix A), prepared on forehand were posed to the group, setting off group discussions as well as individual thoughts. The data was gathered through note taking.

Individual semi-structured interviews were held with two nurses at two wards that were not included in the observations.

The questions posed were the same as at the group interviews, together with additional questions with the aim of understanding the structure of the wards. Special attention was paid on the focus areas that had been discovered during the observations.

3.1.2. Analysis

As the observational research generated an extensive amount of raw data, the first step of the analysis had to consist of sorting and categorising the data. The KJ analysis constitutes a powerful tool for turning big quantities of data into a lucid structure and was thus chosen for this purpose. The raw data was read through and all facts of interest; actions, thoughts, quotes, and general impressions were written down on post-its and put up on a wall, sorted into categories. As the work proceeded, the categories were refined and restructured until a number of focus areas could be identified.

The focus areas were then further elaborated by theorising them and sorting them into one of the following four categories:

- Specific problem
- General problem
- Specific fact
- General fact

Specific, in this case, means problems and facts that target a specific situation or need and general refers to findings that concerns the whole system and may influence any future solution.

A deepening analysis of the focus areas were then performed using the Pre-study support scheme (Rexfelt, 2010). Every question was answered for each and everyone of the focus areas, generating a deepened understanding for the problem or fact, its generality, extent and seriousness.

Data collection of formal responsibilities and educational background were made on the three primary clinicians: nurse, nurse assistant and physician. This, in order to better understand divisions of work and implicit attitudes among the staff.

3.1.3. Synthesis

The total information flow around the nurse was summarised and visualised in a figure, pointing out the major problem areas. Based on the analysis, the amount of focus areas were narrowed down to those of certain relevance for the nurses' work situation and with possibilities of being addressed within the product range of Ascom. These focus areas were verified with graphical visualisations of the quantitative data, using infographics, as well as with revealing examples of the qualitative data.

3.1.4. Evaluation

The findings was evaluated and verified with several external sources. Presentations and discussions were held with personnel at several different departments within Ascom, with the aim of comparing the result with previous findings and internal knowledge.

The presentation, with additional notes was sent electronically to the shadowed nurses, hospital management and the previously interviewed researcher in healthcare improvement in order to collect opinions.

The last step of the evaluation phase was to set implications for the coming concept development in phase II. This was made in collaboration with the Feature Management department.

3.2. Interim Results

3.2.1. Observational Research

The intention of the shadowing was to keep a broad perspective with as few prejudices as possible. The fieldnotes written were rich and covered a wide range of information, from the precise hour an alarm signal was turned on or off, to the topics of conversation at the coffee break. Nurses and wards were given code names to guarantee their anonymity.

The complete set of fieldnotes is not included in this report, as it was considered too extensive and unstructured to be of value to anyone else than the observer itself. However, a short example of the structure and content is presented below.

15.32 Nurse Cecilia is in the medicine room. A patient calls. She goes out in the corridor to check the display since there is no one in the medicine room. The dishwasher alarms that it is done.

15.39 Nurse Carin comes into the room. "You do tell me if you need help, don't you?" says nurse Cecilia.

15.40 All three nurses at the ward get together at the medicine room and discuss if patient 5:2 is allowed to eat before the treatment.

15.41 Nurse Cecilia checks the medication list at the computer, to make sure that she has distributed the correct medicine and then goes to give it to her patients.

3.2.2. KJ-Analysis

The raw data was categorised with a KJ-analysis (figure 3.1.) generating a number of focus areas.

- Specific problems
  - Alarm fatigue
  - Medicine distribution
  - Walking with information
  - Task interruption
  - Unused function: nurse presence
  - Changing between physical and digital information sources
  - Inefficient information channel from patient
  - Exchange of information with mesosystem
- General problems
  - Fear of technology
  - Inter-professional collaboration
- Specific facts
  - Portable information storage
  - Communication in nursing pairs
- General facts
  - Emotion work

3.2.3. Pre-study Support Scheme

Further analysis of the focus areas through the pre-defined questions in the pre-study support scheme, generated insight of the seriousness of each issue. The complete analysis is found in appendix B.

4. Focus Areas

This chapter includes the final outcome of the observational research. The findings stem directly from the result described in the previous chapter. They are presented according to the research question and a number of sub-questions defined in the very beginning of the chapter.

According to literature as well as interviews with hospital managers and researchers, the current state of organisation development in healthcare deals with building effective and high qualitative structures focusing on the individual patient's experience. Theories and methods for costumer orientation, traditionally used in the business world, have been imported, including for instance the concept of Lean Care. Care units are reorganised and rebuilt in order to implement patient-centred care.

When asked what they would like to spend more and less time on, the nurses in the study answered as in figure 4.1: they want to spend more time with the patient and less with administrational work. Thus, it is evident that the desire to turn care patient-centred is present both at an organisational level, as well as at grass-root level.

This leads to the research question, presented in chapter 1 Introduction: How can the information flow be rationalised to give the nurse more time and energy for the patient?

Answering that question requires some additional questions:

- Who is the nurse and who are her medical colleges?
- How does the nurse work?
- Where does the nurse work?
- What is the information flow and what are its difficulties?

These questions will be answered one by one, in the following sections.

When presenting the findings of the observational research below, all places and people have been given code names to guarantee their anonymity. For the same reason all participants are referred to as

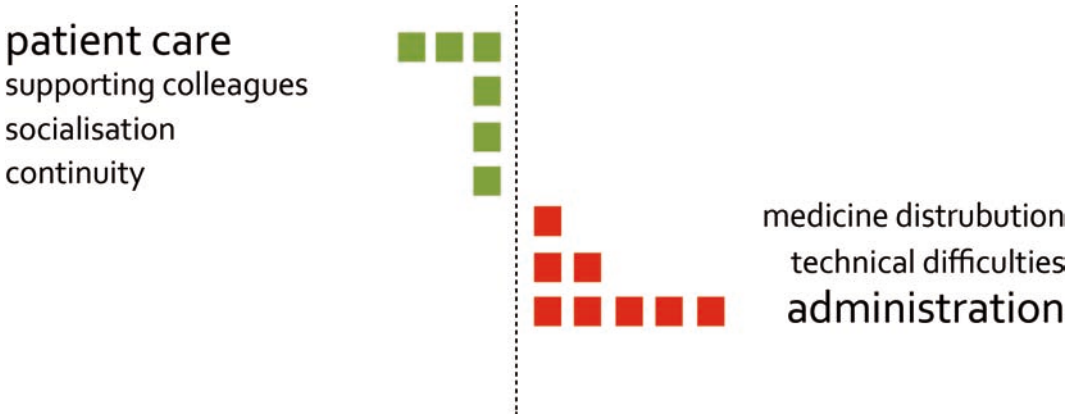


Figure 4.1 Answers to interview question: "What would you like to spend and less time on?"

women, regardless their real gender. As a majority of the participants in the study were women, male names would have been easily identified. When intending a nurse in general, the pronoun *she* is used. This does not mean, in any way, that all healthcare workers are women.

4.1. Who is the nurse?

The nurse and her clinical co-workers are all presented on the opposite page. Below, their professional responsibilities are described further.

4.1.1. The nurse

The nurse acts like the spider in the web at the ward. She takes care of the patients and their medical treatment, incoming and outgoing correspondence, routine work associated with medical equipment etcetera. Several nurses in the study gave voice to that they wished more time with the patients and less time with administrative tasks.

4.1.2. The clinical co-workers

The nurse assistant is the one of all professions, working most closely to the patient. The work is considered gratifying due to the close patient relations, but at the same time heavy and wearying.

As physicians were not included in this study, their work has been studied solely from a distance. Nevertheless, the statement by Glouberman and Mintzberg (2001) (referred to in chapter 2 Framework, section 2.3), that physicians meet their patients during time limited, often scheduled interventions was verified in this study. The physicians often shared their time between inpatient wards and outpatient clinics, resulting in limited time spent with each individual patient.

The role as co-ordinator is a part of patient focused care (see chapter 2 Framework, section 2.3) and aims to support the nurses with the administrative work in order to release more time for direct patient care. The co-ordinator role is either a full-time work for one (or more) person(s) or an alternating task shared between several nurses or nurse assistants. At the studied wards, the co-ordinator worked office hours leaving the administrative duties to nurses and nurse assistant at unsocial working hours.

Nurse

Main responsibility	Fulfill medical ordinations and see to that patients get accurate care
Education	Bachelor degree in nursing care
Patient related tasks	• Surveil patient's health • Distribute medicine • Carry out rounds with physicians
Other tasks	• Communicate with relatives • Keep medical record • Correspond with authorities • Administrate patient treatment
Swedish title	Legimiterad sjuksköterska

Nurse Assistant

Main responsibility	Assist patients with the necessities of a daily life
Education	No protected title, common education is 3 years care studies in upper secondary school (gymnasium)
Patient related tasks	• Assist patients with food, hygiene etc. • Take blood tests etc.
Other tasks	• Look after supplies
Swedish title	Legimiterad sjuksköterska

Physician

Main responsibility	Medical responsibility for the patients
Education	5,5 year medical studies at university and completed medical practice work
Patient related tasks	• Fulfil rounds • Determine diagnosis and treatments • Perform medical interventions
Other tasks	Several
Swedish title	Legitimerad läkare

Coordinator

Main responsibility	Administrate the work at the ward
Education	Nurse, nurse assistant, medical secretary or similar
Patient related tasks	few
Other tasks	• Administer registration and discharge of patients • Handle correspondence • Other tasks within administration and documentation
Swedish title	Samordnare

4.2. How does the nurse work?

Nurses of consumer wards are generally located at one ward where they care for a group of patients together with a number of nurses and nurse assistants. At some work places, nurses are rotating between wards, preferably within the same mesosystem, but in most cases, nurses are employed at one ward only. One or more doctors are affiliated to the ward, but in many cases, they share their time between a few wards and/or outpatient clinics. During office hours, some administrators including i.e. management and co-ordinators work at, or in conjunction with the ward.

Normally the nurses work in three-shift; a morning shift, an afternoon shift and a night shift. The night shift was not studied during the observational research of this project.

4.2.1. Inter-professional collaboration

At all observed wards, patient focused care was practised, however in varying ways. Nursing teams were used at all wards, at some being a pair with one nurse and one nurse assistant, at others a team of three. The nurses had varying thoughts about the working method, some thinking that they did indeed get more time with the patients, some that it was problematic sharing tasks equal with the others in the team. One nurse found it frustrating that she was supposed to do half of the nurse assistant's tasks but still had the solitary responsibility of performing the nurse specific tasks that the nurse assistant is not allowed to do.

"You feel shattered in nursing pairs. Both are doing everything. It is hard to cooperate and share the care when the nurse has to do so much else then care."

A nurse at another ward had more positive experience with patient focused care:

"I like helping the patients and doing nurse assistant work. Patient focused care has given me more time to such work. Not having to answer the phone does a lot!"

At some of the observed wards nurse or nurse assistant had the task of being a so called runner (löpare). The runner does not belong to any certain nursing team and acts as an extra resource, supporting all the nursing teams whenever they need help. Common tasks for a runner could be to deliver tests and assist with care demanding patients.

The physician(s) meet the nurses at one scheduled appointment per shift: the medical round, where the nurse informs the physicians of the current health status of the patients, the physician determining the continued medication and treatments. In addition, the nurse may, and shall as discussed in Chapter 2 Framework, section 2.3, contact the doctor in occasion of sudden health degradations or obscurities.

Physician-nurse relationships has, as mentioned earlier been open to debate. An overall impression when observing the communication among them, was that a strong hierarchy exists as well as a rife feeling of irritation among the nurses towards the physicians. At one ward this

was particularly evident. The nurses compared the morning round with a cross questioning where they had to get into a room full of physicians, afraid of not being able to answer their questions. At this ward, the nurses shied away from calling the physicians when they had questions about patient treatments, they preferred asking each other for help.

4.2.2. A typical day

A workday might appear considerably different depending on the type of ward, the hospital and the state of the day. However, a general working process can be distinguished, that differs quite a little among wards and shifts (figure 4.2):

1. **Report** - The nurse finds out information about her patients for the day. Either she does that by reading their medical records, by getting a verbal report from the previous shift or a combination of the two.
2. **To-do list** - The nurse writes down information about each patient and things that shall be done during the work shift.
3. **Visit patients** - The nurse goes around introducing her self to each patient.
4. **Round** - Together with one or more physicians, the nurse carries out a medical round. Together they go through the health status of each patient and set up plans for proceeding treatments. The round is made either with or without the patients.
5. **Medicine distribution** - The nurse distributes medicine to each one of her patients, according to the ordinations written by the doctor. Medicine is normally given to the patients at certain hours.
6. **Medical record -** The nurse keeps the medical record of the patients, noting the variations in health status, special events and results of tests and treatments of each patient.
7. **Report -** When the next shift starts the nurse hands over the responsibility of the patients either by giving the next nurse a verbal report of their health status, or, in cases when they just read

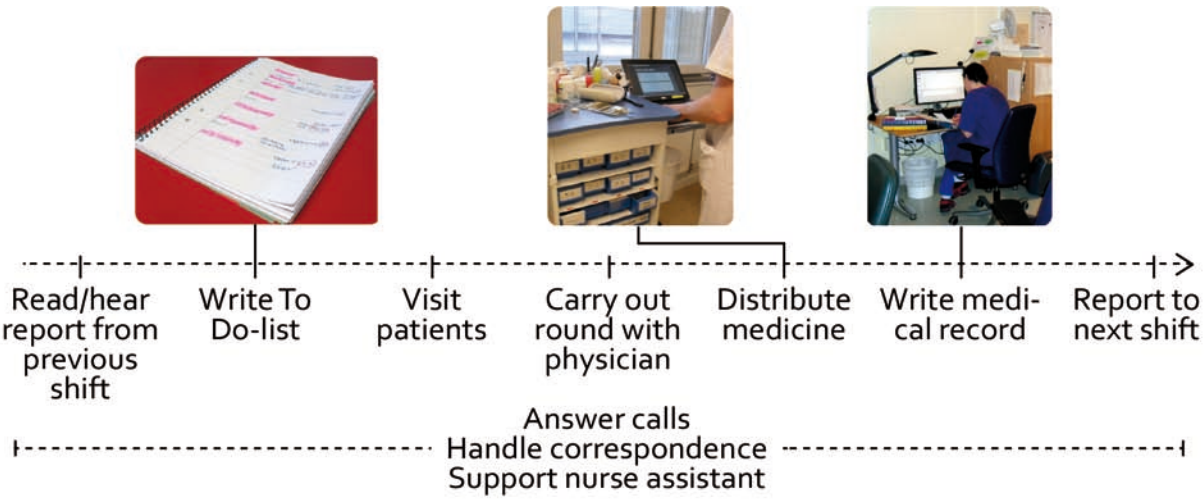


Figure 4.2 A general workday for a nurse

the medical records, by being available for answering questions.

Parallel with the scheduled tasks the nurse has to handle the following tasks as they occur:

- **Answer calls** - Patient calls and automatic alarms notify the nurse about that the patient needs to be taken care of.
- **Handle correspondence** - The nurse is responsible for handling correspondence in and out of the ward. This may include telephone calls from relatives and authorities, letters and emails as well as internal and external documents and formularies.
- **Support nurse assistant** - When the nurse is available, she supports the nurse assistant with the general patient care.

4.3. Where does the nurse work?

The six studied care units are situated at five different hospitals in cities in southern Sweden and represent hospital organisations of varying size, complexity and degree of specialisation. All of the care units belong to the category Consumers; wards that are responsible for the general care about a group of patients. Consumer wards collaborate with a number of other wards, both Consumers and Providers, to provide the patients with appropriate care. Due to this variety of communication, consumer wards were considered appropriate for a study of this kind.

Of the studied wards, four (Ward A, B, C and D) constituted sites for deep studies including shadowing and group interviews. At the other two (Ward E and F) study visits and individual interviews were made. They are all presented below and in more detail in appendix C. In addition, figure 4.3 - 4.6 pictures the atmosphere on Ward A, B, C and D respectively.

Ward A

Ward A is technologically heavy ward specialised in taking care of seriously ill new-born and premature babies. Hospitalisation may last everything from a few hours up to several months. Aiming to imitate the atmosphere of the babies' natural environment, the womb, the ward A is calm and low-voice. Due to the fragile condition of many babies, physiological monitor alarms are taken seriously and pagers are passed on to colleagues as a

Figure 4.3 Atomsphere at Ward A

Figure 4.4 Atomsphere at Ward B

nurse leaves the ward, takes a break or goes to the toilet. Ward A is in the front edge of organisational development, educating all employees in Lean Care and planning a reconstruction with the aim to build a conjoint, patient-centred perinatal centre.

Ward B

Ward B is a rather big ward with a high patient flow in and out. The patients have a rather high average age and the duration of hospitalisation varies quite a lot. Physiological monitors are used for patients with cardiac diseases; though due to their extensive alarming the nurses only cope with a maximum of five. The patients are divided into three groups with a nursing pair each. A reconstruction is planned, including three separate nurse stations for each nursing pair respectively.

Ward C

Ward C is situated at a small hospital and specialised in endocrinology; diseases associated with the hormone system. The ward is connected to the dialysis clinic and patients are recurrently transferred between the two. As kidney diseases are treated, some patients have alcohol problems. The ward has no automatic alarm systems, however a central part of the care is to surveil blood sugar levels and provide the patients with insulin.

Ward D

Ward D is a big, new built transplantation ward at a university hospital, specialised in care before and after organ transplantations. Ward D treats kidney-, liver-, and lung transplantations while its twin ward treats heart transplantations. The two wards are physically and organisationally conjoint. The ward is modern with in total six modules (three at each twin) with a nursing pair and separate, open nurse station in connection with the patient rooms of each module. The ward has a silent nurse call system, where calls are directed to the pager of the responsible nurse.

Ward E and F

Ward E and F are both intensive care units, where patients are kept under intensive supervision, than at regular care units. Ward E is a coronary care unit for patients with heart problems and Ward F is a cardiopulmonary unit for patients with heart- and/or lung deceases. Since both ward E and F treat patients with unstable health status, the physiological monitoring, connected to Ascom pagers, is essential.

Figure 4.5 Atomsphere at Ward C

Figure 4.6 Atomsphere at Ward D

4.4. What is the information flow and what are its difficulties?

The total information flow around a nurse can be described with the following components:

- the sender of the information
- the receiver of the information
- the way the information is transported
- the content of the information

As for the last component, it is in this study simply described as information that is of medical or co-operative value for the clinicians. The emphasis lies here instead on the three first components, which are all pictured in figure 4.7.

The figure shows the total information flow observed during the observational research at ward A. The figure build on the microsystem theory, where the nurse is included in the microsystem. The mesosystem consists of care units directly connected and within the same specialisation as the ward: in this case the perinatal centre, whereas in the macrosystem, units that are connected to more than one mesosystem are located. Outside of the macrosystem are additional instances, differentiated from the intramural care but still connected to the health and well-being of ward A's patients.

The nurse sends and receives, as can be seen, information from all levels of the structure and the frequency of information

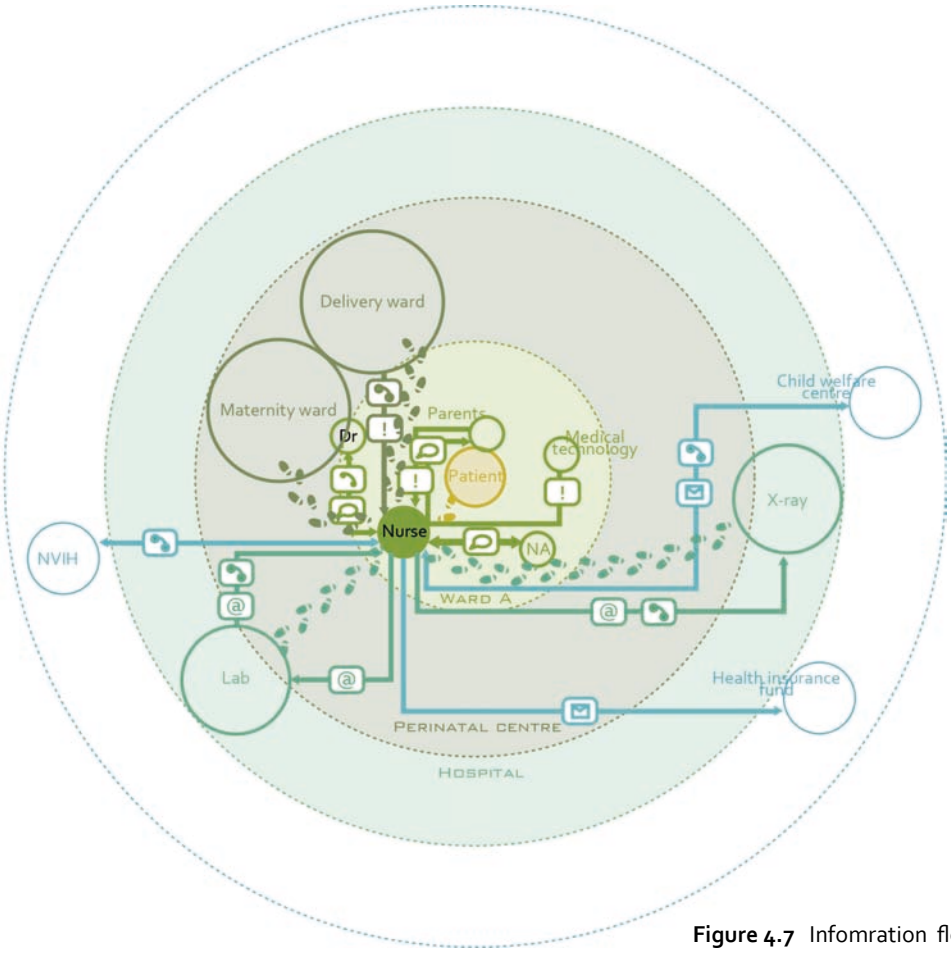


Figure 4.7 Infomration flow at ward A

exchange is generally decreasing with the distance from the patient. However, the nurse communicates with all instances on a virtually daily basis.

With some instances, the nurse has face-to-face communication. This concerns both instances within and outside of the ward, implying that the nurse needs to translocate within the hospital. With other instances, the communication is mediated. The different artefacts used by nurses for mediated communication, are presented in the following section.

In this case, ward A served as example. Even though the wards all have different specialisations and different communication needs, the over all structure is more or less the same. Nurses need to communicate with several different instances in all parts of the healthcare system and act as spiders in the web regarding the information flow in and around their ward.

4.4.1. Overall Aspects

4.4.1.1. Emotion work

The empathic, calm and positive mindset of the nurses, in literature referred to as emotion work, was clearly present at all of the wards. The way of approaching patients as well as colleges was with a caring attitude, with often dealing with soft values.

"Can you help me with a blood transfusion when your are done? Do you have time? Do you feel that you have enough energy?"

A consequence of when professional collaboration is built on the basis of empathy is that it gets highly dependent on the emotional and social skills of the individual. One nurse

described that not only the social comfort, but the actual work efficiency of her nursing pair as being highly dependent on the person she was currently paired up with. If they did not get along well, the whole workflow got malfunctioning.

Another aspect of emotion work is discreteness and respect. The type of situation a nurse may encounter in her work range literally from birth to death and to avoid disturbing delicate situations nurses approach each other and their patients with great carefulness. They prefer face to face communication over telephone calls or alert systems and do not run into other nurses' patient situations without having made an evaluation of its delicacy. This is also one reason to why obtrusive technology, like ringing telephones and beeping alarms, is commonly disliked.

4.4.1.2. Fear of technology

All nurses are individuals and as in the society as a whole, there are more and less technically experienced people. However, among nurses there seem to be a rather widespread dislike of technology. Perhaps this is due to that nurses in general are interested in people and thus less interested in technology, perhaps due to the increasing amount of time new technology requires from the nurse, at the expense of time spent with patients.

"I want to spend more time with parents and children. I am to old for technology."

Nevertheless, in her daily work the nurse need to deal with everything from computer systems for administration and correspondence to technical information tools and vital medicine technology. Many systems coexist, barely compatible with each other. Several systems also fight with poor usability, circumstantial handling and inadequate functionality.

> *"It is frustrating that we have so many different computer systems that we need to log on to with different passwords that need to be with changed in different periods of time."*

Commonly, one or a few nurses are appointed, officially or unofficially, as technical expertise, helping others with technical difficulties.

4.4.2. Problem Areas

4.4.2.1. Alarm fatigue

The amount of audible alarms at the observed wards was indeed stunning. In the fieldnotes, all audible signals were written down with start time and end time. These were then put together into charts, one per ward, as seen in figures 4.8 to 4.11.

The figures show the working day of the shadowed nurse, chronological clockwise in the circle, starting at the coloured arrows. The figure could be seen in that way; hour for hour with the occurrence and length of each alarm, but could also be viewed as a whole, getting an impression of the total percentage of audible signals during a day. The coloured areas are the alarms; the warmer the colour is and the closer to the centre of the picture it has its distinct area, the more important it is for that particular nurse. The grey areas of the chart represent time that the nurse spent out of earshot of the alarms, for example outside of the ward. The walking silhouette above an alarm represents an alarm where the nurse acted as in walking to the patient, answering the phone or similar. The alarms where she silenced the call, for example after checking that a heart curve was normal are not marked in that way. Two notes ought to be made according to the accuracy of the charts: Firstly, the researcher shadowed the nurse and the

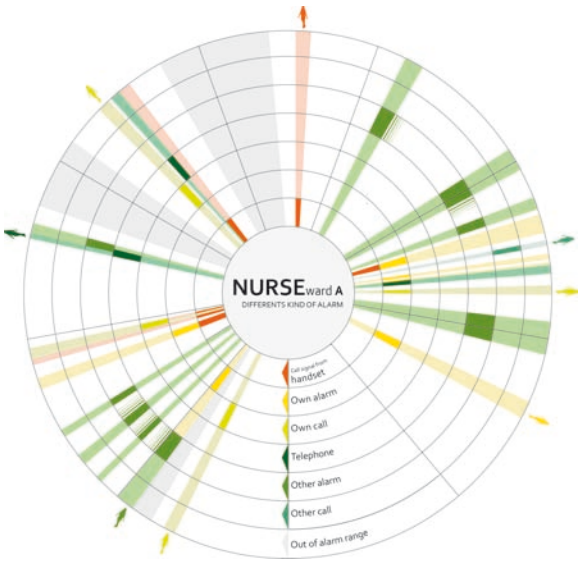


Figure 4.8 Alarms at ward A

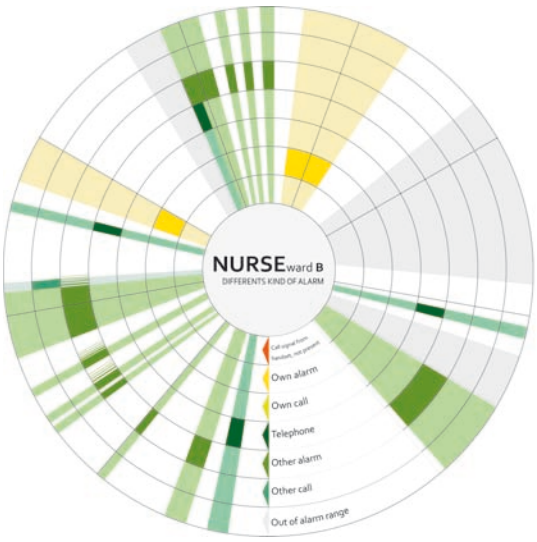


Figure 4.9 Alarms at ward B

alarms shown are thus the alarms that reach the ear of the nurse, not the total alarm amount present at the ward at that time. Secondly, also researchers may suffer from alarm fatigue, implying that all alarms may not be present. There are also some alarms in the charts ending with dashed ends, symbolising that the end of the alarm was not noticed by the researcher.

Ward A (see figure 4.8) has several children under physiological monitoring, connected to monitors at the nurse stations as well as pagers carried by the nurse in each nursing pair. Since premature babies require a calm and silence environment to progress well, at the same time as their undeveloped organs are sensitive and unstable, Ward A struggles with keeping the alarm amount down and as quite as possible.

At ward B (see figure 4.9) the alarm fatigue is extensive. Physiological monitors alarm frequently and under prolonged time. The nurses are so accustomed to the constant beeping that they do not even turn it off when a patient is disconnected and sent off to treatments in other parts of the hospital. The two longest green alarms in the chart, both lasting for well over 20 minutes, were beeping to warn for disconnection as the patients were currently out of the ward. Due to the extensive alarming and the fact that the pagers, connected to the physiological monitors are poorly configured, the nurses choose not to wear them at all.

Ward C (see figure 4.10) does not have any physiological alarms and the chart therefore looks completely different. Nurse Cecilia answered many of the calls from her patients directly, and those that she did not answer silenced after a short while as well, probably due to that some of the other nurses at the ward answered them.

"It's beeping and vibrating all the time so you get disturbed. We don't use them. You have to press to silence the alarms and you don't want to keep doing that all the time."

Ward D (see figure 4.11) does not have any patients connected to physiological monitors, though their twin ward – a heart transplantation ward – has several and monitors showing their patients' curves hang also in the corridors of Ward D. The

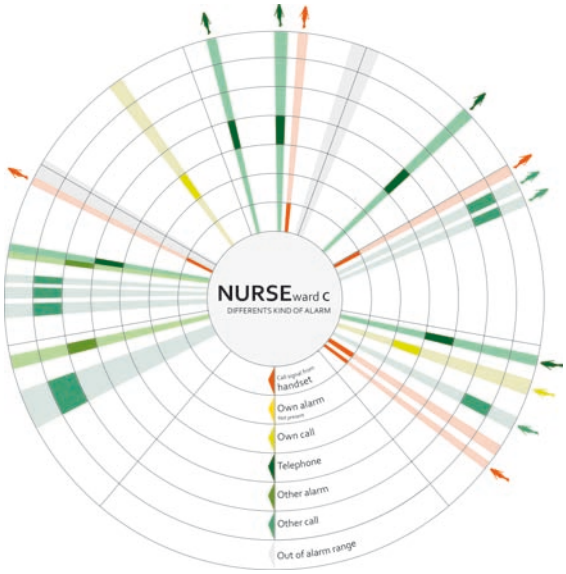


Figure 4.10 Alarms at ward C

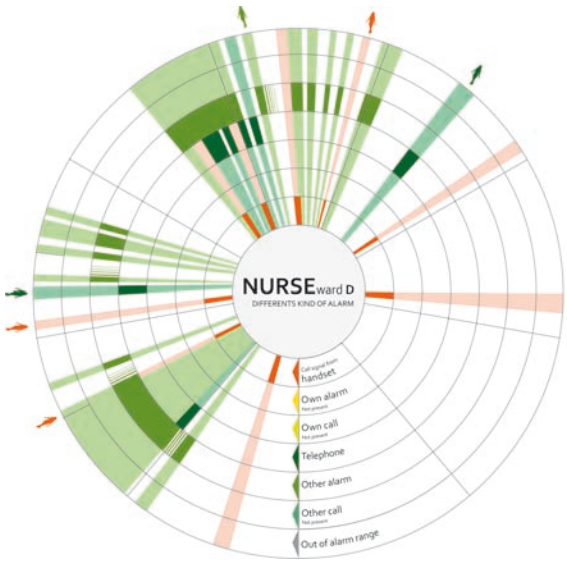


Figure 4.11 Alarms at ward D

alarm in the bottom left of the chart, constantly beeping for well over an hour was (among others) sent out from the monitor mounted in the staff lunch room, where the nurses were gathered for an hour lunch break. On the question if anyone would ever react on one of those alarms, the answer was *"Never, there are eight nurses over there, in control of those patients."* As mentioned earlier, the alarms in the chart show the alarms in the earshot of the nurse. While nurse Doris were walking in and out of rooms, storages and even out of the wards, the situation was completely different for, for instance, the little new transplanted lady lying in her bed in a room with an open door, just a few meters from one of the monitors. The following dialogue took place:

Patient: *"What is that constant beeping?"*

Nurse Doris: *"It's an alarm from the other ward"*

Patient: *"Now it starts again! Can't you turn it off?"*

Nurse Doris: *"Yes we can, but we are so used to it so we don't hear it anymore."*

A conclusion from the observations above, is that the alarm fatigue indeed is extensive and a large amount of alarms remain unnoticed or ignored. It is not in any way due to laziness or ignorance from the nurses; the human mind is designed to detect differences and the effect of constant alarms is thus as if there were no alarms at all. A further consequence of alarm fatigue is that the adjustments that in fact could be made by the nurses themselves to silence the alarms are ignored, leading to even more extensive alarming.

Figure 4.12 Nurse Doris steps one day at ward D

Several nurses answered the question why the alarms were let ringing all the time, with *"We have to have it ringing. It's for safety."* One can ask oneself if the "safety" the nurses refer to, rather is a way of keeping management safe of being accused for not preventing incidents. An alarm that rang, did ring even if no one heard it, or?

4.4.2.2. Extensive walking

Consider the following situation at Ward D, where nurse Doris is supposed to give blood transfusion to a seriously ill transplanted patient:

16:00	Nurse Doris prepares blood and walks towards the patient's room. NA Dina stops her and asks about something.
16:02	At the bed Nurse Doris prepares the blood talking leniently with the patient.
16:04	The pager alarms. She lets go of everything and runs to another room. False alarm, back again.
16:05	She goes to get more syringes.
16:11	Something went wrong and she goes to get other tools.
16:13	X-ray department calls on the telephone in her pocket. She answers and takes notes on a paper.
16:23	The pager calls while she is injecting the syringe. She ignores it.
16:27	She is done and leaves the room.

During the 30 minutes the procedure takes nurse Doris has to leave the room at three occasions. Looking at the total amount of steps taken by nurse Doris on a seven-hour workday in figure 4.12, it becomes evident that the example above is not an exception. Nurses do walk a lot. The lines in the figure shows nurse Doris' movement within the ward, while the dots indicate the purpose for her walking. Red dots means taking care of patient; yellow, fetching objects; turquoise, fetching medicine and the two shades of green, fetching and leaving written information. The size of the dot indicates how long she has been in at each place.

Looking at the figure it becomes evident that nurse Doris walks to fetch or leave written information at more occasions than she walks in order to care for a patient. When the nurses were asked if they ever missed objects or information when in patient rooms, they verified the picture: "*Yes! Everything*", *"Everyday"*

Figure 4.13 shows an overview of what the nurses reckoned that they missed the most. The nurses were allowed to answer several things or none at all and the amount of answers shown in the figure is thus not equivalent with the amount of responders. However, it is evident that the nurses considered information to be lacking to a significantly higher extent than objects, when in patient rooms.

As a conclusion, it can be stated that the site of action, the patient rooms, is not the same

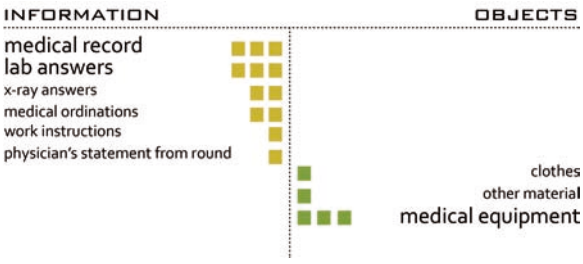


Figure 4.13 Answer to yhr question "Do you ever miss objects of information when in a patient room

as where information and objects are kept. Thus the nurses need to walk within the ward a lot, leading to work inefficiency and fatigue. Further, within the fact that information is not stored where it is needed lays a patient security risk. To temporarily store information when moving, nurses often write it down on formularies, notes or even on the back of the hand. Getting a number wrong in a medicine amount or a vital parameter might get serious consequences. An even higher risk exists when the nurses memorises information that should be used or written down somewhere. As they so commonly get interrupted in their works, such information is easily forgotten.

Nurse Bea helps NA Bibi to put a patient on the scale. NA Bibi asks nurse Bea if she can write down the weight in the medical record and she writes down the number on the back of her hand. She serves breakfast to the patient and together the two nurses continue serving breakfast to the rest of their patients. 15 minutes later, nurse Bea goes to change a drip of another patient, which has run empty. She needs help with zeroing the machine and goes off looking for the technical responsible nurse. As she is walking down the corridor she suddenly notices the numbers written on her hand. *"Oh I forgot!"* She finds NA Bibi in a room and asks her if she has written the weight in the medical record. She has not, so nurse Bea goes to the nurse station, logs on to the computer and writes the weight in the patient's medical record.

4.4.2.3. Correspondence with macrosystem

Nurses correspond with the macrosystem on a daily basis, in general mostly the x-ray- and laboratory departments. Consider the following situation taking place at Ward C on a late Sunday afternoon:

A patient needs an x-ray. A physician writes a referral on the computer at the nurse station and prints it. Nurse Cecilia takes it and walks to floors down to the x-ray department. She rings the bell and hands over the referell to the assistant radiographer opening the door. She returns to the ward. A while later the x-ray department calls on the telephone, telling that they are ready to accept the patient. Nurse Cecilia accompanies the patient down to the x-ray, waits until the procedure is done and brings the patient upstairs again. About an hour and a half later, she believes that the result may be ready and she brings a key with her back downstairs. Outside the door of the x-ray department, there are post boxes; one for each ward, and nurse Cecilia unlocks the box of Ward C, finding a paper with the result of the x-ray (figure 4.14). On her way back up to ward, she pages the physician who calls back. Cecilia reads what is written on the result to the physician. It is possible for the physician to check the result directly at her computer, but the start-up of the software is so slow, so in the normal case it is faster simply reading it on the telephone. Back at the nurse station nurse Cecilia attaches the referral on a binder with a paper clip, so that the ordinary physician will see it, as she returns Monday morning (figure 4.15).

The procedure for handling correspondence with x-ray and laboratory departments differs from hospital to hospital, but all of the observed wards have similarities with the example above. It is not a far-sighted conclusion that it in the modern IT society can be considered a rather inefficient work procedure.

A main issue is that a general attitude towards computers in healthcare seems to be that information is stored digitally, but as soon as it shall be handled it is printed, written down on a paper or a formulary or in some other way made analogue. A in the case above, the digitally written referral was printed in order to be sent to the x-ray department and the result was printed out and put in the post box. This even though the result in its digitally format can be viewed at any computer at the hospital (including the ones at the nurse station, although the nurse does not have a password to that particular software).

"We thought that we would be paperless when we got the computers, but it didn't get that way."

Another problem is that there are no notifications when a result is ready to be collected. The nurse has to know that it takes about an hour, remember the time or write it down on her to-do list, and then go to check if it has arrived.

4.4.2.4. Nurse call

When a patient wants to contact the nurse for any reason, (s)he pushes the red nurse call button (figure 4.16) causing a signal either in the corridor or at the nurse's pager. This signal might mean anything from that the patient wonders when the doctor will come to that (s)he cannot breath. Especially, at Ward A the shortcomings of the communication method were evident. The patients there are young, mostly healthy parents and can thus be considered a type of critical users, having high demands on the nurse call equipment.

Figure 4.14 Post box outside x-ray department

Figure 4.15 X-ray answers attached on binder

It is though true that a sick, old person will never be as willing and able to interact with complex technical systems, however the lowest level of knowledge among sick and elderly will dramatically increase within the nearest future. It is possible that in a few years, patients experienced with chat and sms, will prefer such a way of communicating with then nurse, before pushing a red button.

"It is outdated to just press a button when you want something"

Also in the case of the nurse, the nurse call signal has its shortcomings. It constitutes attention demanding, but hollow information as it only communicates *that* and *where*, but not *when* or *how important.* Thus, the nurse is not given the opportunity to overlook her current work situation and prioritise among tasks.

4.4.2.5. Nurse presence

The nurse presence system, used for nurses to be able to locate each other is not extensively used, according to figure 4.17.

Figure 4.16 Ascom teleCARE

Ward	Display	Nurse presence
Ward A	not used	various use
Ward B	not used	not used
Ward C	not used	used under special conditions
Ward D	not used	not used
Ward E	not used	intentions of using
Ward F	not used	not used

Correctly used, the green button (figure 4.16) should be pressed to log into the room when entering. This will silence a possible call and display the room as under presence of a nurse. When going out from the room, the green button should be pushed again to log out.

The reason for not pushing the nurse presence button was recurrently told to be the risk of forgetting to press it again when exiting. Such a risk is easily verified; when walking out from a room, the mindset is not that one is on its way out from a room, but rather on the way into the next. Pressing the button does not give any visible feedback, such as for example pressing a light switch and it does thus constitute an action without neither motivation nor feedback.

As the functionality of the nurse presence system is set, the red nurse call button switches function to an alarm, while nurse presence is activated. That alarm is the strongest internal alarm present at the ward: when that goes off everyone at the ward lets go of their tasks, running to the room in need. If the nurse presence is accidentally activated due to the nurse forgetting to log out, the next call made by the patient will result in the entire staff rushing into the room. Thus, in addition to the unmotivated and feedback-less action of logging out of a room, it is also heavily punished when forgotten. The nurses'

decision of not activating nurse presence seems reasonable.

At some wards, the habit of not using nurse presence as it is intended is so well founded that the mental model for the entire system has changed. One nurse explained the functionality of the nurse presence button as below:

"When a patient is calling, you walk to the room. When entering, you push the green button twice to silence the call."

Due to the varying use of nurse presence, the validity of the presence display, showing the locations of nurses is marginalised and thus not used at any or the observed wards.

Though, do nurses not need a location system to find each other at the ward? On the question "If you had someone always by your side that was able to tell you anything at anytime, what would you ask?" about half of the answers given, dealt with where colleagues, what they do and if they can be disturbed.

4.4.2.6. Telephone

One interview question was: "What in your work stresses you the most?" One reoccurring answer was the telephone.

"The telephone stresses me the most. You don't get anywhere in your work. It's frustrating and unnerving"

"In fact it's not calls that you have to take, but if you postpone them, they will still return later"

"If I want help I don't want to dial a number and call. I can't stand holding a phone when I hold the child. I just want to press a button"

The constant interruptions of telephone calls from relatives and authorities are considered is a major source of irritation. A telephone is typical example of obtrusive technology, as it is ringing out loud until it is answered. In the Swedish culture it is also considered rude to answer the telephone when in a face-to-face conversation with another person.

4.5. Conclusions and Recommendations

Routines and tools for communication are used in different ways and with varying efficiency. However, when the structural support fails, the nurses show an incredible ability to adapt to the current situation in order to provide their patients with good and safe care. These adaptations are difficult to detect, and are in many cases invisible, also to the nurse herself. Nevertheless, they are symptoms of failing technology, procedures or both and constitute subjects of work inefficiency and sometimes even patient risk.

Inefficiency in information handling as well as unaccomodated and sometimes outdated technical and analogue

communication tools are the reality at many Swedish hospitals. With a rationalised information flow and user-centred design of technical communication tools, dedicated to their context of use, time and energy would be released for increased patient focus.

4.5.1. Recommendations

The following recommendations were made on the basis of the findings in the observational research:

- Give the right information to the right person at the right time and place
- Send information compact messages
- Avoid audible information overload - dare to refuse alarms
- Support structures for portable information storage
- Minimise undesired task interruption
- Minimise need of memorising information
- Avoid unmotivated and far-sighted actions
- Make technology see-through, straight forward and unobtrusive

4.6. Implications for Phase II

As result of the evaluated outcome of phase I, the following challenges were set as prerequisites for the concept development in phase II:

- The final concept should build on the three main values unobtrusiveness, mobility and see-through technology.
- The final concept should be a platform for information handling and a basis for future development of targeted solutions on the Swedish and international market, rather than a solution of specific solutions.
- The final concept should facilitate the demands set on information technology in order to create successful microsystems (see further chapter 2 Framework, section 2.3):
  - Support of core competencies and core processes
  - The right information at the right time
  - Effective communication
  - Multiple formal and information channels
  - Enable feed forward and feed back
- The final concept should address the following areas either by a direct solution or possibilities for future solution development:
  - Nurse call
  - Store temporary information
  - Move information
  - Alarm fatigue
  - Correspond with macrosystem
  - Nurse location
- The concept should constitute a concept product for future healthcare products of Ascom. That is; it should reach a certain level of innovation and act as inspiration, exploring the possibilities of a dedicated nurse communication tool.
- The final concept should be technologically and economically realisable within three to five years. However in case of conflicts with the item above, this limitation should be of lower priority.

Phase II

Use System Analysis

In phase II of the project a concept of a nurse communication tool was developed. Execution and final concept will be presented in this part of the report.

5. Concept Development

This chapter includes the process of the concept development. In section 5.1, the way of the execution is described. Section 5.2 presents the interim results leading up to the final concept.

5.1. Execution

5.1.1. Data Collection

Phase II was initialised with a data collection phase where technological aspects of interest for the concept development were studied.

The concepts of ambient intelligence and calm technology were studied in order to grasp the state of the art in camouflaged and unobtrusive technology. Through internet searches, product examples of the categories above were collected and later put together into an inspirational board.

Knowledge about construction and components included in mobile phones, cordless phones and pagers were gathered through internet searches, visits in shops selling IT equipment and interviews with staff at Ascom

5.1.2. Analysis

A SWOT-analysis was made of the existing Ascom product solutions for healthcare. The analysis was made in order to determine the and future prospects of an Ascom solution to be part of an effective information flow.

A benefit map was put together in a workshop together with two interaction designers at Ascom. The aim of the benefit map was to specify a number or use goals that the solution should support, as well as to create a basis for evaluation of the final concept. The use of a benefit map was chosen in order to set prerequisites for the intended product, though without limiting the actual design. The perhaps more conventional option of setting prerequisites: a specification of requirements, was rejected at this stage, since it sets demands targeted at the product design, minimising the degrees of freedom in the idea generation. As a certain height of innovation was aimed for, it was considered more suitable to formulate the prerequisites in terms of use goals only, allowing a creative first exploration of possible solutions.

To specify the preferred expression of the future solution, a mood board was put together. The expression was intended both for aesthetical aspects of the physical product, as well as for the interaction experience.

Two personas were developed, one ordinary persona and one extreme persona in order to act as targets for idea generation.

5.1.3. Synthesis

In order to generate a span of innovative and new thinking ideas, a brainstorming session was held with six students at the master programme Industrial Design Engineering at Chalmers. The brainstorming consisted of three phases: group discussion, idea generation and

further development of ideas. In the group discussion, the participants were presented to the three terms mobility, unobtrusiveness and see-through technology. They were shown two pictures associated with each term; one that was said to embody the term and one that was said not to. They were then asked to discuss whether they did or did not agree, identifying what factors that determine each term.

In the second phase, the participants were asked to generate ideas about how to solve a number of specific situations. The situations included one of the two personas and were practical examples of any of the following issues:

- receive information
- overlook information
- prioritise information
- send information

Two examples of situations are shown below:

- How can Linda receive alarms and calls without anyone else noticing? (receive information)
- How can Anki check Facebook without being caught by anyone? (overlook information)

The participants were given a few minutes to generate ideas individually and then red them out loud in front of each other. The ideas were written down on notes.

In the third phase, the participants paired up and collected the notes from the previous phase, developing them further.

During the brainstorming inspiration and probes were used, such as portable and wireless technical equipment, pictures from healthcare settings as well as the mood board and inspirational board, described above. The full set-up of the brainstorming can be seen in appendix D.

The outcome of the brainstorming was brought into the next synthesis phase, where they were further developed into three main concept categories. These were presented and discussed on an evaluation meeting with the Feature Management Department at Ascom, where one category was chosen for further development.

As a concept category was chosen, an interaction specification was made, interpreting use goals and actions from the benefit map into product properties. To determine an approach for handling a number of conflicting demands, a demand rating was performed using a triangular matrix. Conclusions were then drawn from the outcome, generating a general approach for the next iterations of concept development.

The detailed concept development was made in several iterations. The concept category chosen was narrowed down to two possible concepts and further into one final choice of concept, through sketching and sketch model building, data collection of technical solutions and evaluation meetings with the Feature Management department. The interaction model was developed through sketching, use cases and a workshop with three interaction designers at Ascom.

Ultimately, the final concept was visualised through a computer aided 3D model of the product shell, illustrations of the digital interface as well as story boards and a stop motion movie showing the interaction model.

5.1.4. Evaluation

An evaluation of the interaction was made using the expert evaluation method Cognitive Walkthrough (CW). An HTA was made on common tasks, one basic and one on a more complex level. A usability educated person, conversant but not involved in the project, then performed the CW. The choice of a third party evaluator was made to ensure objectiveness in the evaluation.

5.2. Results

5.2.1. SWOT-analysis

Objective

To create an Ascom communication solution that contributes to rationalise the information flow around nurses.

Analysis

The complete SWOT matrix is seen in figure 5.1. Perhaps the greatest advantage of existing Ascom solutions is that information is targeted and sent to one receiver only. The information overload is reduced as only the intended nurses are notified about incoming calls and alarms. Yet, even though the overall sound environment is somewhat silenced, using Ascom solutions, the amount of audible signals for the individual nurse might still be high. The current pagers make much noise for little information, by vibrating and beeping, announcing only the fact that something wants the nurse's attention.

As for the opportunities for future products, Ascom solutions possess the possibility of transporting information and provide it to the right person at the right time and place. Both of these tasks were identified as needs in the use system analysis. Yet again, portable communication tools constitute a risk in being obtrusive, disturbing the nurse with incoming calls and notifications. Ultimately, Ascom products, as all other information technology, risk an effort requiring interaction, as the complexity functions increases.

Strengths	Opportunities
• Silent care environment • Targeted information • Assist nurse cooperation • Patient privacy	• Moving information • Storing temporary information • Providing information where it is needed
Weaknesses	**Threats**
• Hollow information • Interupt and disturb	• Obtrusiveness • Effort requiring interaction

Figure 5.1 SWOT-analysis

5.2.2. Benefit Map

The benefit map is visualised in figure 5.2. Seven user groups are identified as being contributors in achieving the aim, however as only nurse and nurse assistant are within the scope of this project, the remaining five have not been further analysed. According to the initial limitation, the needs of a nurse assistant are considered being covered by the needs of a nurse. Thus remains the use goals of the user group nurse, divided into the categories *must*, *need* and *want*. These goals constitute requirements for the future concept to fulfil.

The lowest level of a regular benefit map; Actions, is not part of this version. Actions are possible solutions of each use goal and these were left out until the idea generation phase.

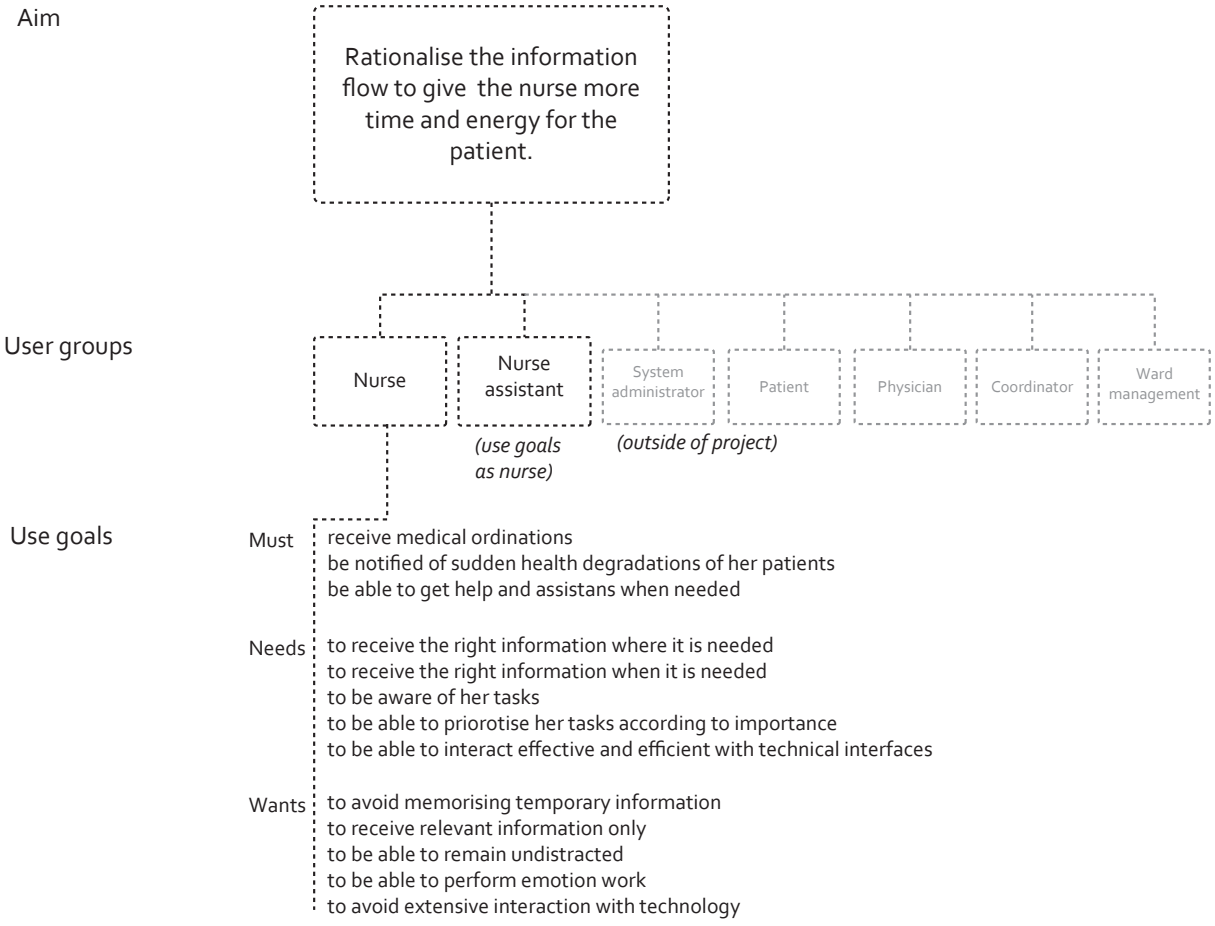


Figure 5.2 Benefit map

5.2.3. Personas

Linda

Linda (figure 5.3) is 38 years old, lives in a middle sized city and has worked as a nurse for 15 years. As long as she can remember she has wanted to become a nurse, and both her sister and mother are healthcare workers as well. Linda has been working in several types of wards, but is most happy working with elderly, trying to make life qualitative and enjoyable also in the final stage of life. After having children, she therefore went back to school getting a masters degree in gerontology.

Linda works methodically and calm, with her own established routines. She is by colleagues described as mild, discrete and motherly.

In her spare time, Linda spends time with her husband and two young daughters, preferably in their little summerhouse, making paintings of mussel shells and driftwood.

Anki (extreme persona)

Anki (figure 5.4) is 27 year old, officially single but always involved with someone, somehow. Currently, a muscular heavy metal fan is the focus of her attention. When she was a teenager, Anki wanted to become a singer or a stewardess. However after two years of working at a café realising that she did not have the motivation to fight for any of her dreams, she decided to become a nurse. She had watched a lot of reality shows from hospitals and pictured herself saving lives of fallen bikers and injured building workers. Though, after four years as nurse she is still in the same medical ward in her old small town. Most patients are old and grumpy and she is exhausted listening to their constant moaning. Honestly spoken, she cannot really see the point in keeping people alive that would be better off dead years earlier.

Anki is frequently on facebook, loves to get her nails done and thinks it is a waste of a Saturday night, not spending out dancing with her girlfriends.

Figure 5.3 Persona: Linda

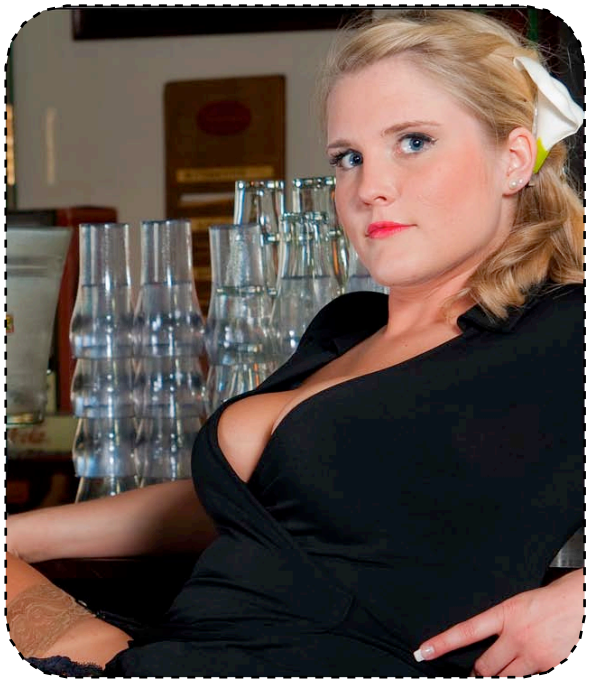


Figure 5.4 Extreme persona: Anki

5.2.4. Mood board

The mood board in figure 5.5 expresses serenity, calmness, unobtrusiveness and transparency; values that should be significant both for the aesthetical expression and experience of interaction in the future product. The device should be an empathic piece of technology, adjusting to the current circumstances, being there whenever it is needed and otherwise silently awaiting its moment.

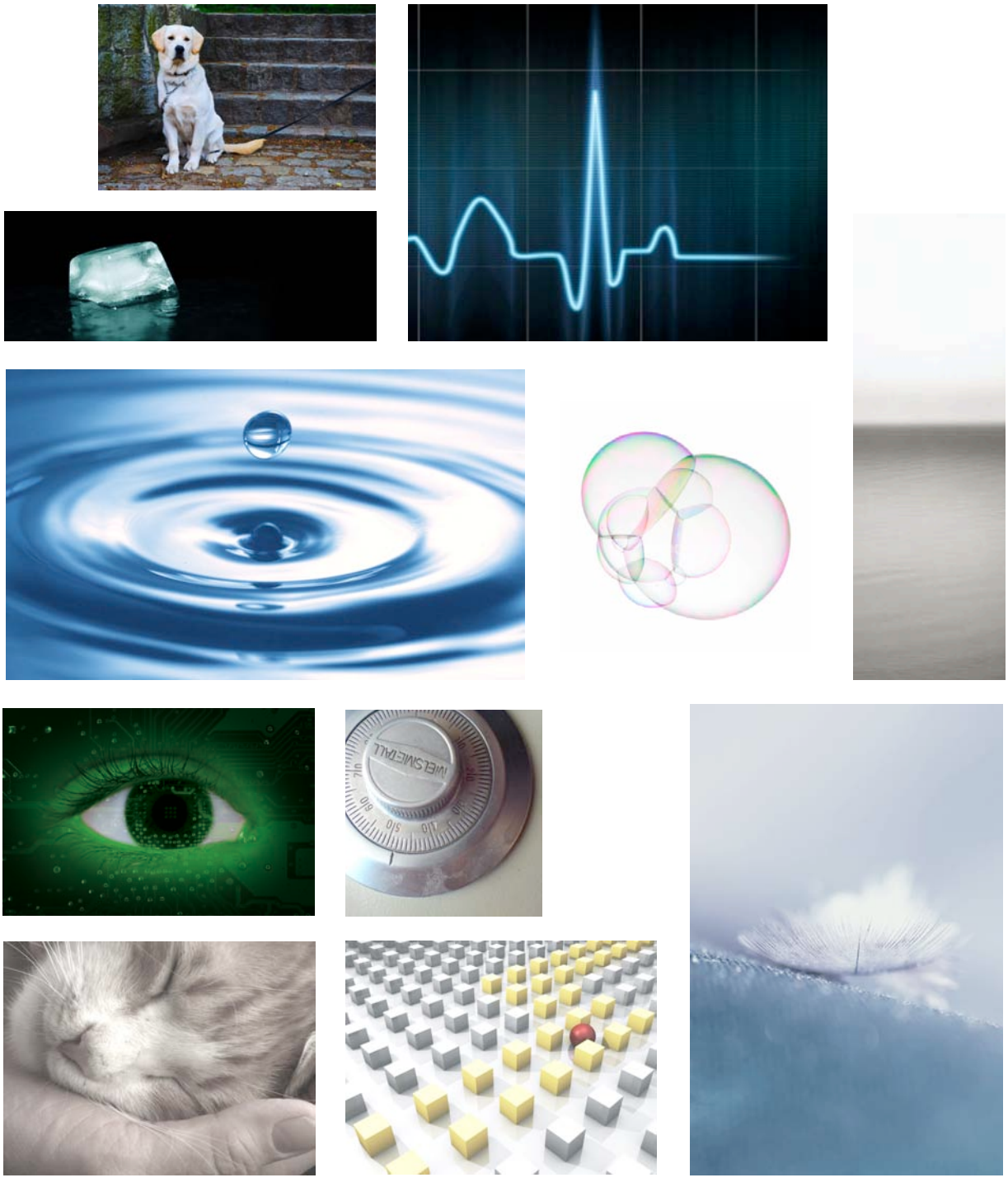


Figure 5.5 Mood board

5.2.5. Brainstorming

The discussion phase of the brainstorming resulted in deeper understanding of the three main values; unobtrusiveness, mobility and see-through technology (the last value was due to comprehensibility interpreted as "technology for those who do not like technology"). Below, a conclusion of the discussion can be found. Appendix E contains the complete outcome, together with the pictures that formed basis of the discussion.

Unobtrusiveness

Unobtrusiveness deals with if something has to be considered or not. A possible threat or something that will act without ones permission is considered obtrusive. If we are not in control, we will more likely find an object or situation obtrusive.

It is also a context dependent thing. Something that is easily accepted in one context, might be obtrusive in another. Unobtrusiveness is about fitting into the environment.

Mobility

There are things that we bring along to use and things that we bring along *and* use, i.e. there is a significant difference between portability and mobility. A laptop for instance, is packed down and brought along to be used somewhere else, while a mobile phone is used while it is brought along. The difference is that the mobile phone is instantly ready to be brought as it is, its very purpose is to be carried around. The functions in it are developed with the aim of being used as we move. Thus, while walking to the bus, it is possible to check an sms in the purse, but not to check the emails on the laptop.

See-through technology

Technology is see-through when it acts according to our expectations. We are adapted to the world around us and if we do not know what else to expect we count on that technology will follow nature laws and the way the analogue reality works. Hence, we are used to that the effort, matches the aim of the task: moving a rock is harder than lifting a tiny stone. We are used to that there are multiple ways to reach a goal, and that it is possible to reach it even not if not the most suited was chosen: if we are not able to lift the stone, we will push it on the ground instead, dealing with the ugly marks it left behind. Also, once we have lifted our first stone, we expect all stones to be lifted in the same way, no matter colour or sort. We expect consistency among similar objects.

The idea generation phase of the brainstorming, resulted in a number of ideas for further development. A selection of sketches is found in appendix F.

5.2.6. Concept Categories

Further development of the ideas generated in the brainstorming resulted in three concept categories, presented below. A selection of sketches from the idea generation process leading to this result, is found in appendix G.

Concept Category I: Call-Response

Call-Response is a concept covering the core necessities of nurse communication, see figure 5.6.

It has an analogue, non-technologic appearance, see figures 5.7-5.9 challenging the common idea of information technology as something with a screen and buttons.

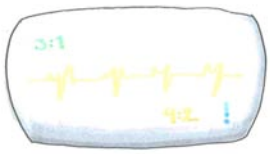


Figure 5.7

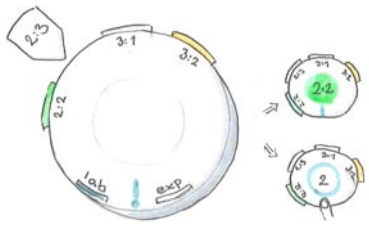


Figure 5.8

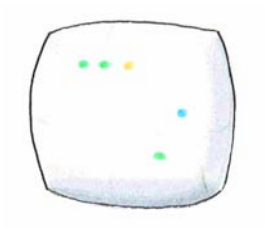


Figure 5.9

The interaction is intuitive and physical, completely without buttons, menus and even text. Incoming information such a calls and alarms is taken in as colour coded light alarms, see figure 5.10, and they are easily silenced, with a single intuitive action, see figure 5.11. Patients are assigned to the device by physical items, as in figure 5.8, that are taken from a common place and put into the device. Changes in the work distribution are then easily made, simply by handing over a patient's item to another nurse.

Figure 5.10

Figure 5.11

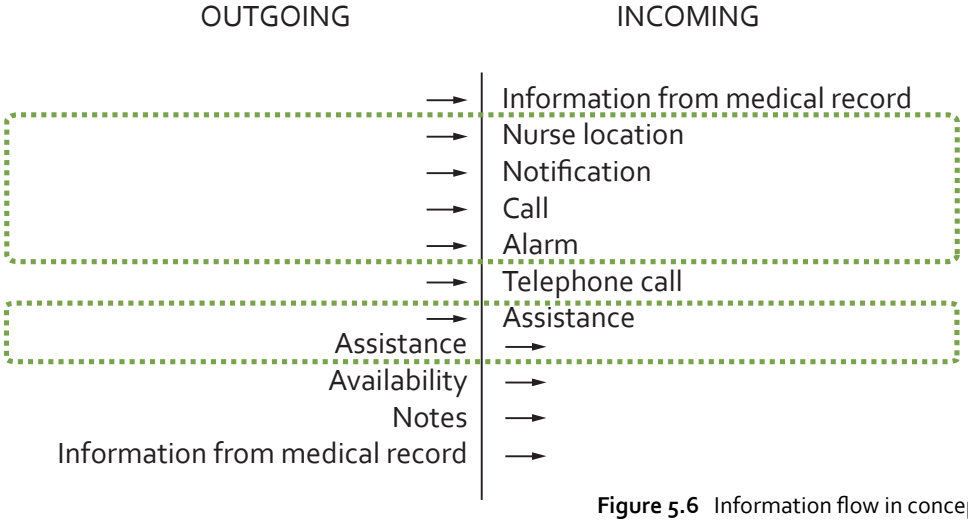


Figure 5.6 Information flow in concept category I

Concept Category II: Full Interaction

Full Interaction is a concept that allows the nurse to send and receive information in multiple ways, see figure 5.12.

The concept is similar to a smartphone and has a touch screen to enable rich and usable interaction, see figure 5.13 and 5.14.

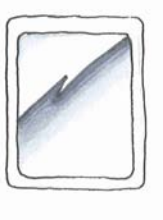


Figure 5.13

Figure 5.14

Various kinds of information can be viewed for each patient; e.g. call- and alarm history, physiological curves, vital parameters and personal information (figure 5.15). Information can be entered and stored, either through free text entry or pre-set formularies such as for example entering vital parameters (figure 5.16). The devices are connected to each other, enabling shared to-do lists and call forwarding.

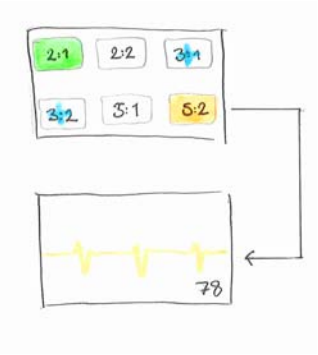


Figure 5.15

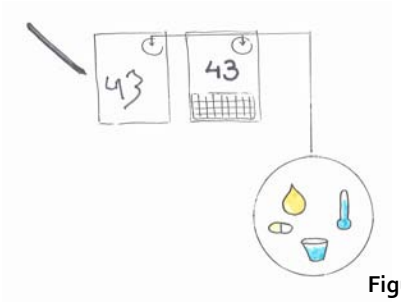


Figure 5.16

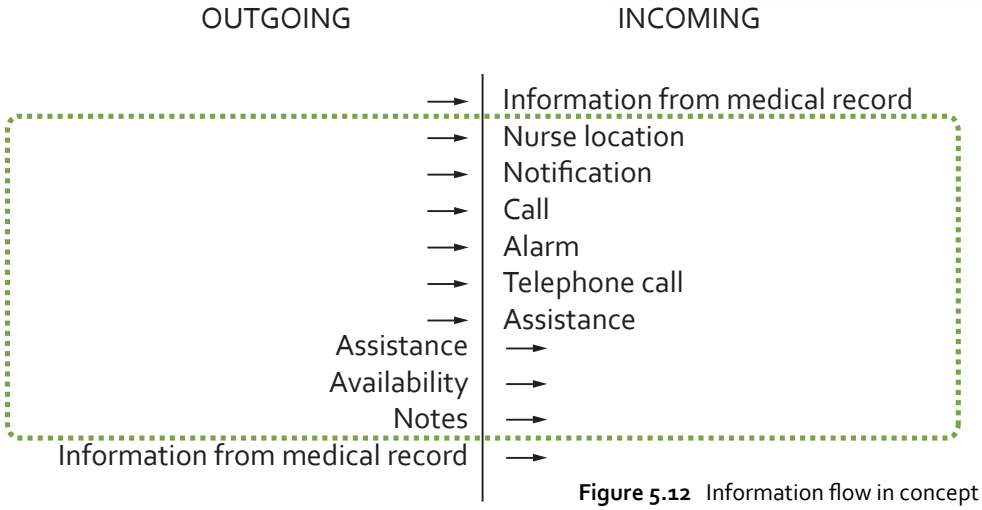


Figure 5.12 Information flow in concept category II

Concept Category III: Communication Solution

This concept is a full communication solution, possibly made as a collaboration with a company developing presentation screens. It enables the nurse to manage her complete information flow through a series of screens and devices, see figure 5.17.

Figure 5.18

The nurse carries a mobile device, similar to the Call-Response concept category, see figure 5.18, that manages calls, alarms and nurse assistance enquiries. When in a patient room, the device is put in a docking station with attached screen (figure 5.19). As the device is docked it goes into presence mode, enabling others to locate the nurse to that particular room and adjusting incoming call- and alarm signals to appropriate level and modality.

Once the device is docked the screen is automatically logged in, in a nurse mode, enabling the nurse to send and receive information about the patient, view lab test answers, medication lists, medical record etcetera. Similar screens may be located at nurse stations, receptions and physician expeditions etcetera, accustomed for the use in each particular context.

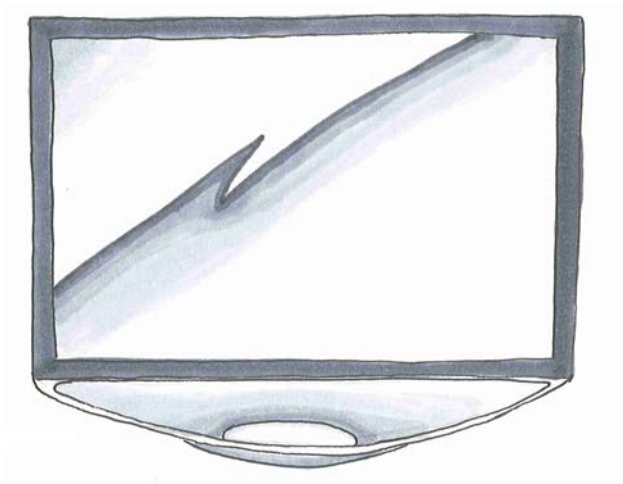


Figure 5.19

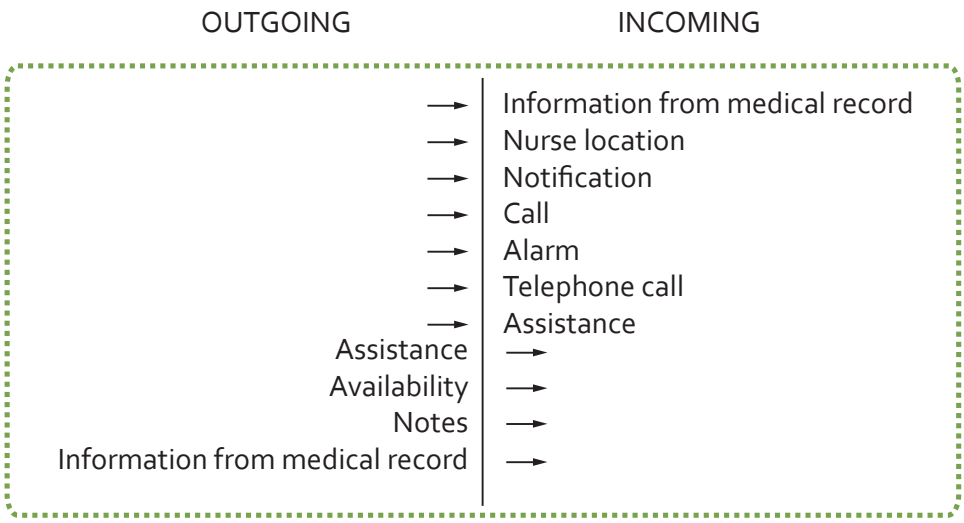


Figure 5.17 Information flow in concept category III

5.2.6.1. Choice of concept category

An evaluation meeting with the Feature Management department concept category I as being the most interesting interaction-wise, though with a drawback in its limited functionality. Category II was considered the most realistic as a future product for Ascom, however with a risk of getting an extensive and complex interaction model. Category III was said to be the most interesting according to functionality and possibilities. However, it requires a collaboration with a third party, making it organisationally difficult and vulnerable.

The decision was made to bring continue with a fusion of concept category I and II, bringing an increased level of interaction possibilities into the intuitive frame of category I.

5.2.7. Interaction Specification

An interaction specification with 26 demands specifying functionality and characteristics of the interaction, was made. The demands were ranked with a triangular matrix, the seven highest ranked demands being listed below in descending order:

1. Receive and alert about physiological alarms
2. Receive and alert about patient calls
3. Provide information about location of calling/alarming patient
4. Attach on body
5. Minimise obtrusiveness
6. Allow silencing of alarm
7. Allow nurse alarm

Ranked lower, were demands concerning more advanced functionality, such as input and receipt of larger quantities of information. This clearly implies an unobtrusive solution with clear distinction between the simple handling of basic functions and more complex interaction.

The full interaction specification, can be seen in appendix H, sorted both according to demand category and ranking. The complete triangular matrix is seen in appendix I.

5.2.8. Interaction principle

Based on the concept category chosen, the ranked interaction specification and principles of calm technology, an overall interaction principle was elaborated, described below.

The first part of the interaction principle is the concept of sleeping technology; technology that symbolically hibernates and awakens first when it is called for. The device should step back and forth between the peripheral and centre of attention (as the principle of calm technology), not only when it comes to distributing information, but in its very appearance of being information technology.

The second part of the interaction principle deals with the ostensibly conflicting

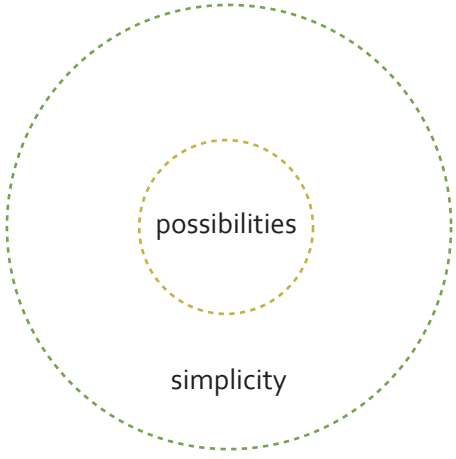


Figure 5.20 Interaction layer principle

properties of concept category I and II; intuitive interaction versus rich functionality. The solution derives from the ranking of the interaction requirements in section 5.2.7, and is visualised in figure 5.20. The interaction consists of an outer shell of the most important functionality, performed with simple and intuitive handling. The shell is named *simplicity* in the figure, and nurses without need or interest in more functionality should manage the necessary communication solely by operating there. The second level, called *possibilities*, is an inner kernel of extended functionality, allowing a more complex interaction. There should be a clear distinction between the two levels, letting the user actively choose when to leave *simplicity* for *possibilities.*

A conceptual concretisation of the interaction principle above was made, using a slidephone (figure 5.21). The user is notified *that* information of some kind is received, *where* it came from and *what* it is about, just by looking and listening to the device. By sliding the telephone open, *how* the information is formulated can be viewed. The user may then move into the level of *possibilities* by pressing a button, opening a number of functionality options.

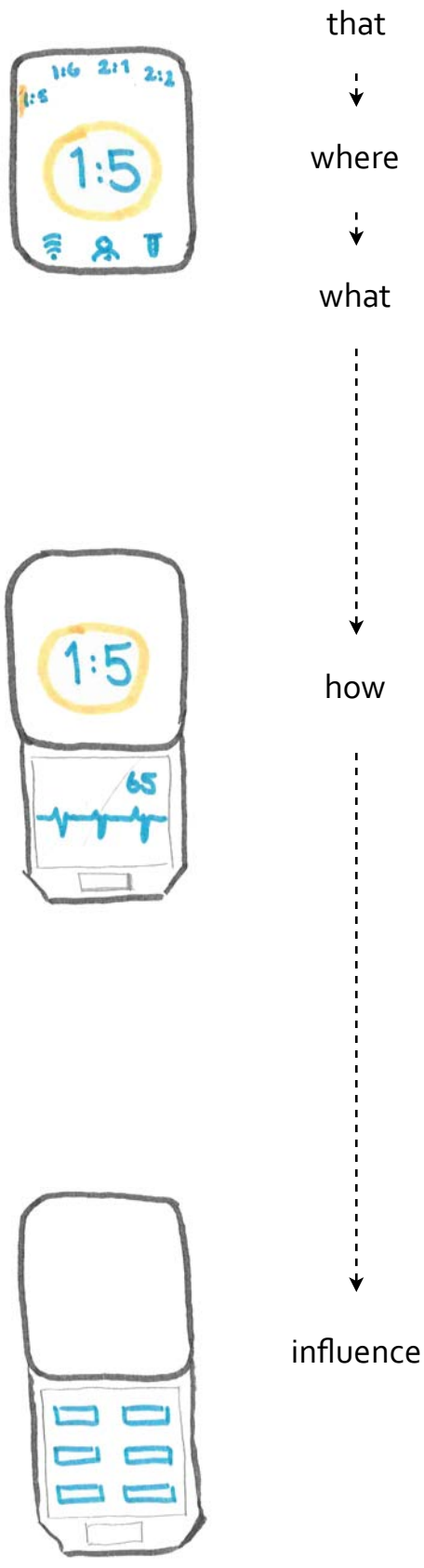


Figure 5.21 Interaction concept

5.2.9. Product Concepts

Further development of functions and interaction principle, led to two possible product concepts, described below.

Concept I: Smartphone

The basic functionality of the smartphone concept (figure 5.22) is similar to the slidephone, except the fact that everything is located in the touch screen. Thus, calls are answered and further information requested by a gesture on the touch screen. As the *possibility* button is pushed, the graphical appearance on the screen changes, in order to differentiate the *possibility* mode from the *simplicity* mode.

Concept II: Slidephone

The slidephone (figure 5.23), evolved directly from the interaction concept shown above, consists of two halves. The upper has an oled screen under a reflecting surface, resulting in that the graphics on the screen shines through, but the screen itself remains hidden. Thus, when no information is recently received, the device is appears hibernating and un-technologic.

The lower half contains a touch screen and one button to open the *possibility* mode. As a telephone call, a physiological alarm or another notification is received it is visualised with a colour coded pulsating light and graphics on the upper half of the device. Sliding it open, reveals information about the event, or answers the telephone call. The incoming information can be rejected by covering the device with the hand. Pressing the button opens up a menu of different advanced functions, such as taking notes or requesting more information.

Figure 5.22 Interaction concept

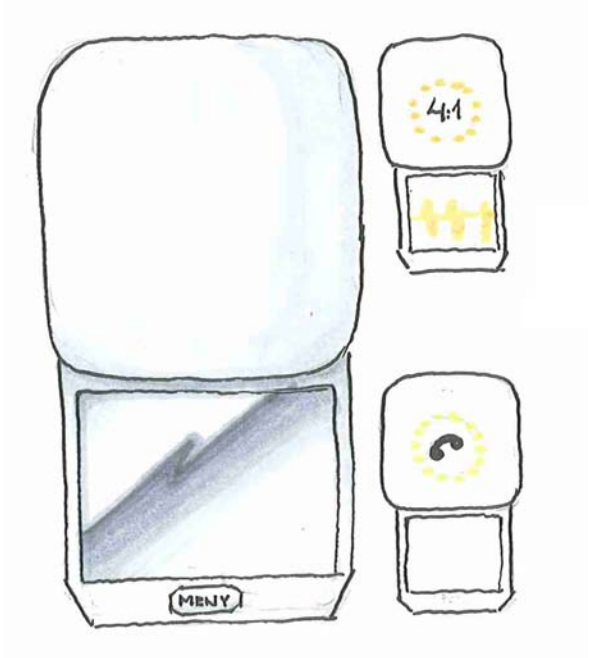


Figure 5.23 Interaction concept

5.2.9.1. Choice of Product Concept

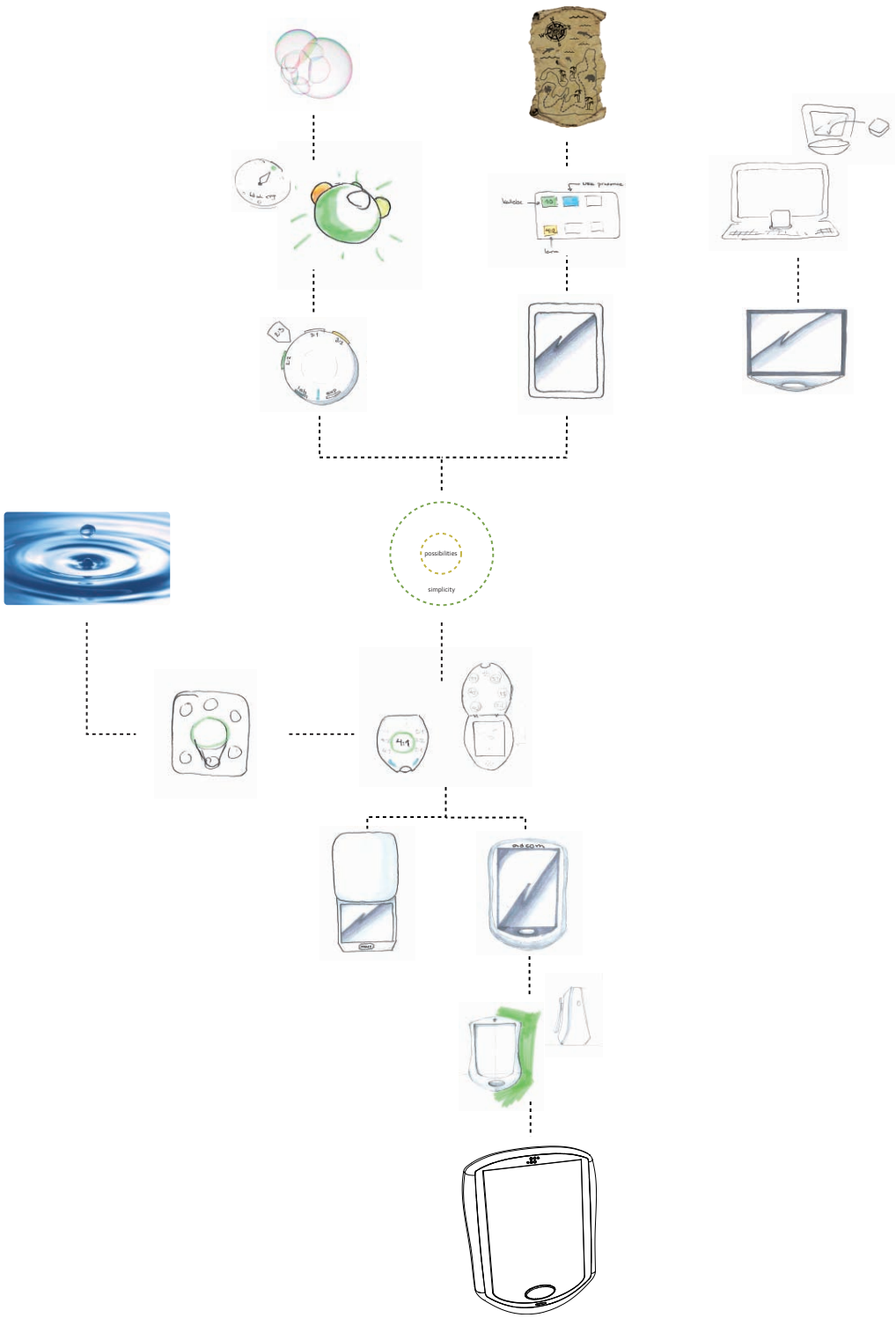
Both of the product concepts have their pros and cons and their suitability from a usable, economical and technical perspective was evaluated in several iterations, as they were further developed. A list of the pros and cons discovered for each concept, at the time of the concept choice is shown in the table below.

The greatest advantages of the slidephone is it usability properties, enabling sleeping technology and intuitive physical interaction. Disadvantages, though, are the mechanical and electronic difficulties, caused by the slider. Ultimately the smartphone was chosen, due to its technical simplicity, and further development was planned to enhance its usable properties.

Property	Slidephone	Smartphone
Realisability		+ in line with company strategy
Economy	- 2 displays - touch sensor required - slide mechanism	
Durability	- sensible slide mechanism - long length of stroke in slider - glossy product shell	- risk of breaking glass shield
Interaction	+ physically slide open	- digital only
Product emotions	+ sleeping technology + clear distinction between simplicity and possibilities	+ non technical
Visual appearance	+ camouflaging white-blue	- black screen
Hygiene	- density problems	+ few slots

5.2.10.Concept Evolution

As a conclusion, the main steps of the concept development are visualised in figure 5.24: the concept evolution tree.



6. Final Concept

In this chapter, the final concept is presented. Section 6.1 describes the product design, including hardware aspects like visual appearance, components etcetera. In section 6.2 the interaction is demonstrated, including descriptions of the functionality of the product. Ultimately an evaluation of the interaction aspects is presented, in section 6.3.

The final concept is called MYco (figure 6.1). It is a nurse communication assistant that enhances and supports the natural communication ways of a nurse's daily work. It does not claim to take over communication, nor does it demand the centre of attention. MYco understands the sensitive context of a hospital and by simple gestures of the nurse it does as she demands. By being covered by a silencing hand, MYco quietens immediately; by being shaken in frustration it assists the nurse by calling for instant help and by being put aside during a sensitive conversation, MYco leaves the nurse and her patient undisturbed, alerting about calls in the most discrete way.

MYco is everything but a beeping, vibrating technical gadget; it is a well-educated piece of information technology, respecting the sensitive processes of nursing care and supporting the fragile network of human communication.

Figure 6.1 MYco

6.1. Product Design

MYco handles several information sources including patient calls physiological alarms, telephone calls and messaging. Furthermore, it can, through software development, be adapted to communicate with several other information systems.

MYco has two visible interaction surfaces: one touch screen, representing the centre of interaction, and one button, allowing the user to change between use-modes. However, thanks to sensors, vibrator and led light, the communication between MYco and its user is not limited to screens and buttons; the interaction is holistic, involving their whole bodies.

MYco is a small, light weight device, easily fastened on clothes with a clip. It is 7,3 cm high, 5,5 cm wide and 1,5 cm deep. (figure 6.3)

6.1.1. Visual Appearance

The overall visual appearance of MYco is discrete and serene, with a slight touch of modern stylishness (figure 6.2) . Its rounded, slightly curved profile expresses a soft, friendly and well-balanced design, fitting unobtrusively into the healthcare environment.

Further, MYco has a strong consistency with the visual brand identity of Ascom. The ergonomic outline and curved lines follow the form language of Ascom healthcare products, as does the ice blue colour and the aluminium coloured button. The shaping of the speaker holes on the front side of the device, is playing with Ascom's common formation of holes that decrease in size with the distance to the centre. Being one of few detailed form elements on the device, the speaker holes give MYco a touch of edgy attitude. At the clip, the Ascom logo is sculptured, in line with the rest of the current product family.

6.1.2. Product name

The product name MYco, sounding almost like a personal name, personalises the device. "MY" indicates that it is not anyone's device, but my device in particular. "Co" associates to co-worker or co-pilot, but also to communication, collaboration and co-operation.

Figure 6.2 MYco

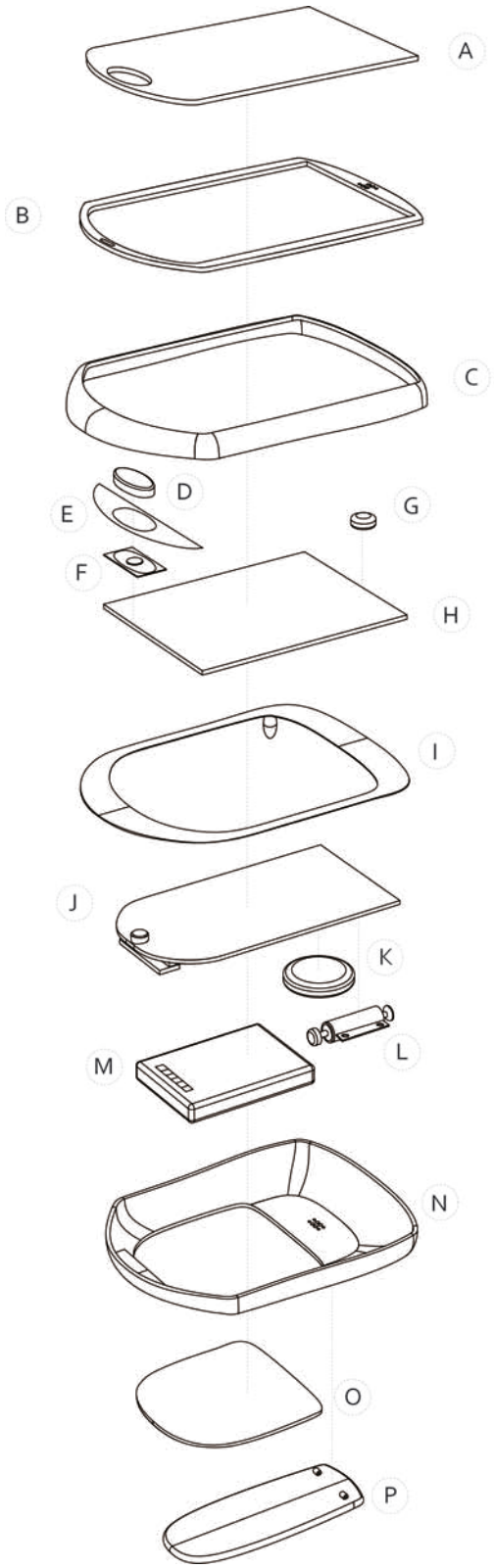
Figure 6.3 MYco

6.1.3. Components

The exploded view in figure 6.4 shows the components of MYco. It consists of an outer, plastic shell in four parts (B, C, P and Q in the figure). Part B, C and Q are ice blue and half-matte, while part P is semitransparent, revealing the led light beneath it. Part Q, the battery flap is removable in order to change battery.

The display is a 2,4 inch QVGA oled display (part H), allowing high quality graphics and thinner depth of the device in general. The display is a capacitive touch screen, allowing multi touch; i.e. understanding of gestures with multiple fingers. It is covered by a scratch resistant and reflection protected glass shield (part A), extended to cover the area around the button as well.

There are two sensors; an accelerometer and a proximity sensor, allowing MYco to sense and adjust to surrounding circumstances. A location system, consisting of detectors mounted at particular locations within the ward, allows MYco to sense and communicate its current location. Possible technical solutions for such a system is either DECT location, enhanced with additional equipment for more accurate positioning, or RFID tags. Further electronic components included in the device are circuit board, two speakers; one for audible signals and one for voice transmission, microphone, vibrator and battery that is loaded through the loading adapter on the back of the device.



A	Glass shield	L	Vibrator
B	Frontside shell	M	Battery
C	Ledframe	N	Backside shell
D	Button	O	Battery lap
E	Black foil	P	Clip
F	Button relay		
G	Speaker		
H	Display		
I	Led foil		
J	Circuit board		
K	Loud speaker		

Figure 6.4 Exploded view

6.1.4. Economical Concerns

Due to the limited market the healthcare segment constitutes a communication device like MYco has its limitations in production cost. The current d62 handset, marketed by Ascom has a certain production cost, defined the sum of purchase price of all the included components. Taking into account, that MYco offers a significantly higher degree of freedom in software development, and that it is likely to be produced within three to five years, implying lower component costs; it was given a maximum manufacturing cost of double the cost of the current handset, counted with today's costs.

No exact numbers were calculated but qualified estimations were made, based on comparisons with d62. In fact, the two devices have many components in common; including the basic electronics, speakers, accelerometer and possibilities of DECT location, however with some increased demands of capacity in MYco. In addition to that, MYco includes an oled touch screen, a proximity sensor, an RGB led with light guide film and possibly some additional components for the location functionality. With the timeframe in mind it is considered reasonable that the economical limitations are managed.

6.2. Interaction

The digital interface of MYco is divided into two parts: a basic, patient centred mode and a more advanced, nurse centred mode. In the patient centred mode, all core activities of the daily nursing work, can be performed. The nurse centred mode, on the other hand, provides extended functionality and further options. The two modes differentiate clearly from one another graphically, the patient mode sober and uncluttered with black background and the nurse mode more vivid in its light blue. The button below the screen changes between the two modes.

The interaction of MYco builds on- and consistently follows- an interaction model based on the bowls that can be seen in figure 6.5. The smaller bowls, here named option bowls, represent the current options on a particular screen and are as many as the number of choices. When choosing an option it is dragged to the action bowl, the larger bowl in the centre of the screen. Once the option is chosen the user will get the impression of visually falling down through the action bowl, with the screen of the option as an underlying layer.

The screen has visually tactile feedback, where it seems harder to pull an item up from an option bowl than to pull it on "horizontal ground". Once the item has

Figure 6.5 Basic screen

reached the action bowl it will fall down by its side by itself. The effect is, as mentioned, purely visual and a matter of software development, but will give the user the impression of a three-dimensional, physical interface. Further, it enhances the interaction by requiring the most of the activation action in its very beginning, making it easier and easier the closer it gets to its goal: the action bowl. This will both diminish the risk of accidental movements as well as speed up the interaction, the more accurate that it gets.

The prolonged action of dragging, acts at the same time as a screen guard: without the initialisation of dragging one icon to the action bowl, the screen remains locked for interaction.

Due to its high degree of consistency, the interaction model has a significantly high learnability. The guessability, though, is somewhat lower due to the slight amount of visual clues of handling principle and meaning of icons. This is intentional however, as the risk is then lower that sensitive information is revealed, if the device gets in the wrong hands. In addition, the nurses will quickly become expert users, not being in any particular need of high guessability.

MYco allows enhanced co-operation within nursing pairs, by teaming up the devices as well. Simply by holding two devices together, screen by screen, they get connected sharing the same patients, calls and alarms and being standby for instant alerting among them.

6.2.1. Patient Centred Mode

The patient centred mode represents *simplicity* in the interaction principle, and is where the basic operations of MYco are managed. It has a discrete, but yet clear graphic layout focused centred around the group of patients the nurse is responsible for. Each patient is visualised in an option bowl, named by room- and bed number according to the common nomenclature in hospitals.

The functionality of patient centred mode is further described in the sections below.

6.2.1.1. Call Signals

MYco communicates events multi-modal, by visual, audible and tactile signals:

- **Light** – the transparent frame lights up with a pulsating colour coded light, indicating which type of information that is taken in. The light pulsates calmly, with a speed of one pulse per minute, the same speed as calm music or the heart beat at rest. Light is the primary modality for call signals.
- **Sound** – unobtrusive, polyphonic sounds are heard, indicating the importance level of information taken in. However, as sound is a secondary modality the signal are played shortly and discretely, with the purpose of catching the user's first attention, redirecting it towards the visual input.
- **Vibration** – under some circumstances, the device vibrates with the same purpose as sound: directing the user's attention towards the sound.

With help of the built-in sensors, MYco senses the environment and adjusts itself to different call signal modes:

- **Attached on clothes** – light is turned on, sound is on a medium volume, no vibration
- **In pocket** – light is turned off, sound is on a high volume, vibration is turned on. Proximity sensor senses the cloth and accelerometer senses that the device is not in a horizontal position.
- **Do not disturb –** light is turned off, sound is on a low volume, no vibration. The device is left on a horizontal surface, the accelerometer sensing that it is horizontal and still.
- **During telephone call** – light is turned off, sound (from the loud speaker) is turned off, no vibration. The screen is locked and call signals are heard as silently directly in the ear. Proximity sensor senses the ear during the telephone call.

6.2.1.2. Patient Call

Patient calls are visualised by a green light pulsating simultaneously in the led frame and at the edge of the action bowl and the patient's code number shown in the action bowl (figure 6.6). A single sound is heard when the call is initialised, though the light keeps on pulsating constantly.

The nurse may silence the call by covering the screen with the hand, stopping the pulsating light and adding a constantly shining green circle on the edge of the option bowl of that particular patient as a reminder. The reminding green circle stays on until the location of the call is visited.

As the nurse walks through the door of the room were the call was made, MYco detects its location, resetting the call. When one nurse has answered the call, all connected devices reset.

6.2.1.3. Physiological Alarm

A physiological alarm is, similar to the patient call, visualised through a red pulsating light, the code of the patient and a single sound (figure 6.7).

The nurse may silence it in the same way as with a patient call, however if (s)he wants to view detailed information, (s)he touches the action bowl and "falls down" to the physiological monitoring screen, showing current curves and vital parameters. Once the monitoring screen is viewed, the alarm is reset.

Figure 6.6 Patient call

Figure 6.7 Physiological alarm

Figure 6.8 Lab notification

6.2.1.4. Telephone Call

A telephone call is received in the same way as in the two sections above, however with a purple pulsating light and an icon of a telephone shown in the action circle. The call is silenced by covering the screen with the hand and answered by touching the action circle.

6.2.1.5. Other Notifications

Notifications about lab- or xray answers, scheduled interventions or other events is received by the MYco and appears as a short period of pulsating white light and one single sound, accompanied with an appropriate icon in the action circle. Detailed information about the event may be provided by MYco, depending on compatibleness with the transmitting system. In figure 6.8, a notification about a lab answer concerning patient 2:3 is shown.

6.2.1.6. Patient Information

Dragging the patient code to the action bowl reveals the patient information screen (figure 6.9). Here, the physiological monitoring screen appearing during physiological alarm, may be reached at any time.

Vital parameters that are not currently monitored, but manually taken at certain hours are handled in the parameter section (figure 6.10). There, the nurse may enter, track and view vital parameters by simple choosing the parameter tab and either enter a new value or check the history in the graph. The graph may be provided with sensitive limits, clearly showing if a parameter is out of the acceptable range.

6.2.1.7. Nurse Alarm

Nurse alarm replaces the current alarm through the nurse call panel, and is thus the strongest internal alarm available at the ward. The alarm is activated by shaking MYco back and forth until it gives feedback through vibration. The alarm is sent to all other devices at the ward, appearing as a rapidly blinking red light, repeating sound alarms and vibrations. The alarm is announced in the same way, despite call signal mode and covering the screen silences the sound only. Nurse alarm can only be fully reset by the transmitting device.

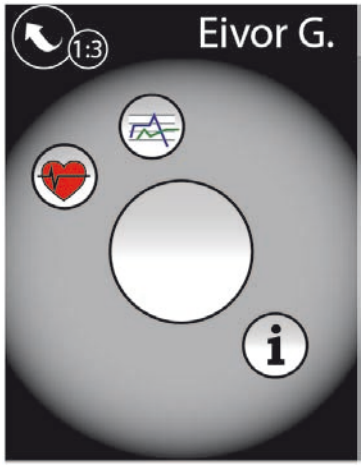


Figure 6.9 Patient information screen

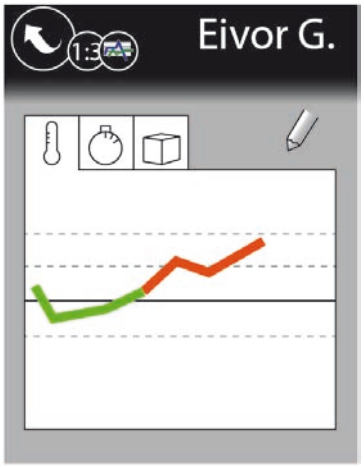


Figure 6.10 Vital parameter

6.2.1.8. Nurse Alert

Nurse alert replaces today's nurse presence as a method for co-working nurses to locate and get in touch with each other. If nurse presence is a passive and public location method - letting everyone see each others presence at anytime - nurse alert is active and between selected individuals only.

Through sensors in the entrance of selected rooms, the presence of MYco is detected. As the two devices of a nursing pair are teamed up, as described above, the nurses within the same nursing pair may locate each other by the nurse icon in the central bottom part of the screen (see figures at the previous page). Additional persons of particular importance may be added to the nurse alert function. In the pictures at the previous page, the nurse icon in the bottom right represents the "runner": the nurse that assists all nursing teams.

Figures 6.11-6.13 shows the functionality of nurse alert: A nurse in need of assistance, as nurse 1 in room 1 in figure 6.12, drags the nurse icon into the action bowl. The bowl turns blue and shows the location of nurse 2 in the same team, in this case room 2. Nurse 2, becomes aware of the alert by a sound, a blue pulsating light and the blue edged action bowl with the location of nurse 1 (figure 6.13). If nurse 2 is occupied, she simply covers the screen with the hand, resulting in a visual sign of denial in nurse 1's device. If she, on the other hand, is available to assist her colleague the two nurses may meet in person and discuss their matter face to face.

Through its unobtrusiveness, discreteness and simplicity, nurse alert gives space for personal communication and emotion work.

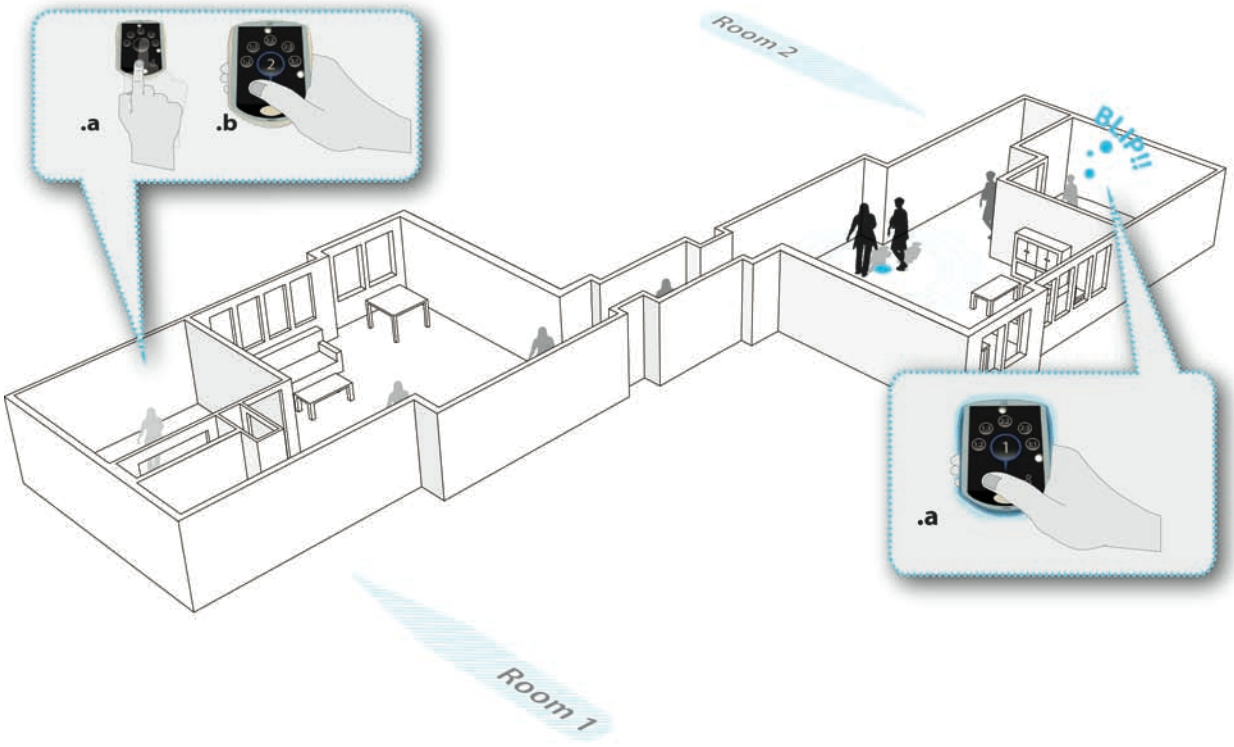


Figure 6.11 Nurse location in a ward

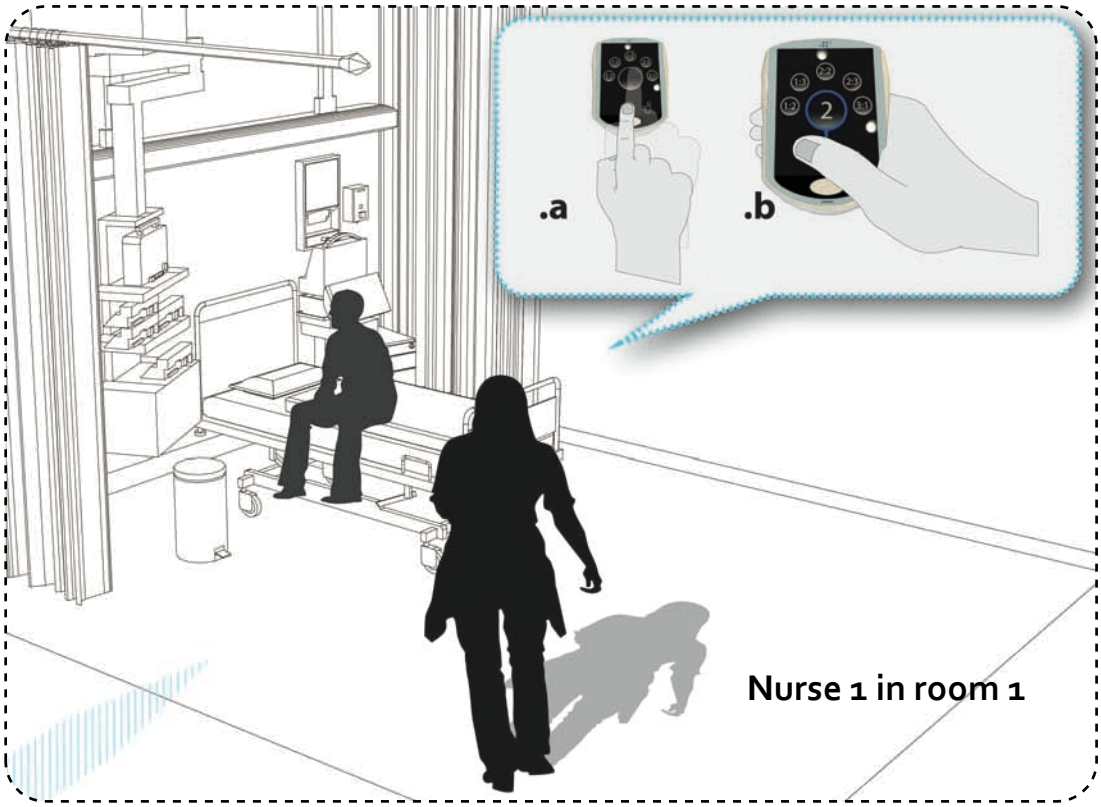


Figure 6.12 Nurse alerting colleuge

Figure 6.13 Nurse receiving nurse alert

6.2.1.9. Patient Manager

Patients are assigned and over-viewed at patient manager monitor. The screen; a computer screen with resistive touch, sensing distinct contact by sharp objects, may be located at for instance at the reception. The patient manager shows an overview of the patients that are currently at the ward, named by their code numbers, and to which device(s) they are assigned to. A patient that is not connected to any device, is distinctively highlighted and possible calls and alarms are publicly broadcasted directly via the screen.

Patients are assigned to MYco simply by tapping the device onto the icon at the computer screen. This function comes in handy as new patients are registered at the ward, or as nursing team change configuration e.g. before night shifts or weekends.

Configurations of the information flow is made through the patient manager, including assigning physiological monitors to a certain patient, connecting patient information with their medical record etcetera.

6.2.2. Nurse Mode

The nurse centred mode represents *possibilities* in the interaction principle, and is where more advanced functionality of MYco is managed. It has a more vivid and colourful layout than the patient centred mode, indicating that the full functionality is activated. The nurse centred mode is presented to the user under the name MYtools, as seen in its initial screen (figure 6.14). The options are sorted according to function and are presented in the option bowls.

Each patient is visualised in an option bowl, named by room- and bed number according to the common nomenclature in hospitals.

The functionality of nurse centred mode is further described in the sections below.

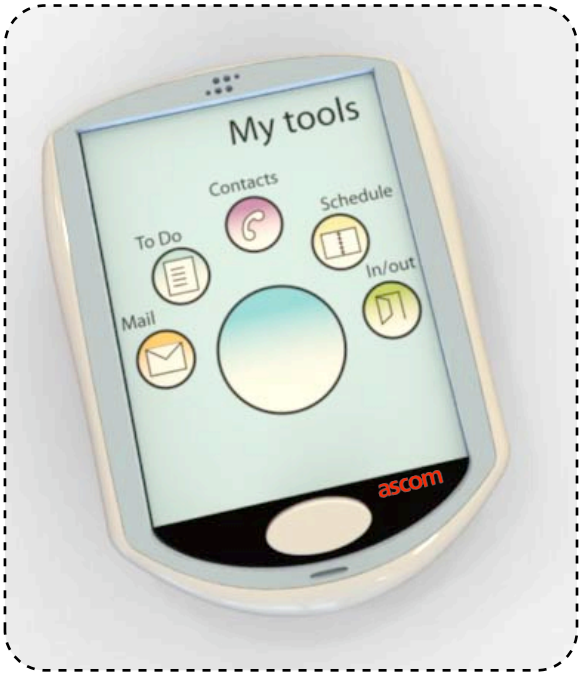


Figure 6.14 MYtools

Figure 6.15 Contacts

6.2.2.1. MYcontacts

In MYcontacts, relevant professional roles are represented (figure 6.15). A telephone call to a specific contact is made by dragging the contact icon into the action bowl.

The functionality of MYcontacts could advantageously be extended to involve text messaging and an alert function, similar to nurse alert.

6.2.2.2. Other features

Several other features could be added under MYtools, preferably as software applications specially adapted to the type of ward, the organisational structure and information systems in use. Conceivable possibilities are:

- To-do list, containing upcoming events, routine tasks and special responsibilities, possibly synchronised among the nurses
- Email
- Calendar with work schedules
- Time-clock with possibility of clocking in and out
- Specialised features for particular responsibilities, e.g. transport service, xray assistants, district nurses etcetera

6.3. Evaluation of Interaction

As the ultimate part of the project, the usability of the interaction was evaluated. Usability is, as discussed in chapter 2, Framework, section 2.2, consisting of three parts: effectiveness, efficiency and satisfaction.

The efficiency – the effort required to perform a task – was evaluated through HTA and CW and is presented in its complete form in appendix J. The following two tasks were evaluated; both in patient centred mode, one basic and one more advanced:

- Check curve when receiving a physiological alarm
- Type in fever value

The evaluation did not predict any usability problems with the first task. A minor comment was made regarding the risk that the pulsating light, indicating the alarm, might be out of the visual field of the nurse. However, with the remark that the additional audible signal most likely would compensate for that.

Regarding the second task, the only concern was the risk that the nurse might not understand that an icon has to be dragged from the option bowl to the action bowl in order to be selected. Thus, it was confirmed that the guessability is not of the highest possible level, however, as the nurses are likely to reach an expert level in a rather short period of time, it does not constitute any particular risk. As mentioned earlier, it was intentional to keep the guessability on a bit lower in order to minimise the risk of unauthorised use.

The two remaining factors of usability: effectiveness and satisfaction, was not considered in the evaluation and are further discussed in chapter 7, Discussion.

7. Discussion

This chapter enlightens the project from a critical perspective. In section 7.1, the execution is discussed, evaluating the use of methods and lessons learned. The discussion is divided in sub-sections according to phase. In section 7.2, the results of the two phases, respectively is discussed. The chapter ends with recommendations for further work.

7.1. Execution

The execution of the project proceeded mainly as planned and included interesting studies and many lessons learn. The fact that the project was conducted by a single person, did mostly not imply any disadvantages. The scope and limitations were well adjusted to one person and when needed great support was provided from tutors, fellow students and staff at Ascom. Yet, it became clear that some activities, especially the formal requirements needed in every master thesis, involved en extra effort since they were conducted by one person only.

7.1.1. Project Plan

The project plan with phases and tasks planned on a weekly basis, was kept and followed throughout the entire project. The decision to put a considerable emphasis in phase I, implying that it was not just a pre-study, but an important part of the final result, turned out well. Ascom showed a great interest in the results and several presentations of the findings were held at the company.

It was also a good decision, not to plan phase II in detail until phase II was completed, since the outcome had were hard to predict on forehand.

7.1.2. Phase I

7.1.2.1. Literature Study

The literature study was conducted as the very first step of the project execution. The aim was to study theories about communication and organisational structures in healthcare. As such a study could fill a whole thesis itself, radical limitations had to be made. One definition of communication was chosen, as well as one theoretical view of hospital organisations: the microsystem theory. However, they turned out to be well suitable as a basis of understanding information flows in hospitals.

One issue should though be discussed. In ethnographical research it is suggested that literature studies should be made after the observational research. This, in order to minimise the risk of being biased by prejudices and to allow the researcher to gain theoretical knowledge about phenomena observed. This study was not intended to be proper ethnographical research, but one may still ask oneself if the knowledge gained on forehand, regarding for example extensive alarming and inter-professional collaboration problems, did colour the findings.

7.1.2.2. Observations

When it comes to the sensitive subjects of healthcare and nursing, observations is a

suitable method to use. Interviews with questions such as "Do you ever ignore heart alarms?" are not likely to generate a properly true picture of the actual situation. The nurse's high degree of personal involvement through emotion care, together with the fact that (s)he might not even be aware of her adaptations to failing technology, most likely obstructs interview- or questionnaire methods. Throughout the observations, as well as the interviews, emphasis was put to act as an ally with the nurses, being on their side and understanding their problems and difficulties.

In shadowing it is, as the name suggests, intended that the researcher should be as invisible. Self-evidentially it is not possible, not to affect the situation at all; simply the presence of a person following you, taking notes of what you are doing would most likely change anyone's behaviour. It is though hard to tell, to what extent the presence of the shadow affected the nurses. Nurses are used to shadowing; the method is used widely both in medical research as well as in nursing education and in several cases, other nurses at the ward did not question the presence of the "shadow". However, joking comments like "Don't write this down now, but…" and "So you are here spying on how we work?" suggest that the shadow was not completely shadow-like after all.

Shadowing is not, and does not claim to be, an objective observation method. One nurse is shadowed, and every situation is seen from his or her perspective. This has the advantage of getting passed numbers and statistics and retrieving the actual situation of the individual user, however its subjectiveness should be kept in mind.

In five of the six wards visited (three of the four wards observed), the nurse to be interviewed or shadowed was picked out by a manager. One may ask oneself if "super nurses" were picked. At least at two wards, the technical responsible nurse was chosen as subject, implying that (s)he was particularly well-informed when it comes to the present technology and probably also structured and well-performing as nurse in general. However, as the shadowing lasted for between seven and fourteen hours (the last divided in two days) at each site, the general atmosphere as well as other nurses work methods were taken in as well.

7.1.2.3. Analysis

In the analysis, the large quantity of data had to be structured and distilled into a number of issues. At some occasions conflicting data was found, as for example when a problem was observed, but denied as being a problem when asking the nurse. The analysis then comes down to a judgement of the researcher only, being a possible sources of error.

7.1.2.4. Evaluation

To verify the findings of phase I the result sent to the shadowed nurses, their managers and the researcher interviewed, asking them to comment. Due to time limitations this was not made until early summer and as this report is written, reply has only been received from the researcher. Possibly this is due to vacations, or busy schedules during the last weeks before vacation. Furthermore, discussions about the result have been held with employees at Ascom, with experience from healthcare issues. However, without comments from

actual users, a true evaluation of the findings has not been properly achieved.

7.1.3. Phase II

Phase II was performed in several iterations, narrowing down the ideas to a final concept. Scope and time limitations were well calibrated to the time available and a high degree of realisability was achieved, as wished by Ascom

7.1.3.1. Idea Generation

The main event of the idea generation process was the brainstorming held with other students at Industrial Design Engineering. Since a limited time was committed for idea generation a method was chosen that was likely to generate innovative and powerful ideas quick and efficient. It turned out as a success and several ideas could be brought along to the concept development.

7.1.3.2. Further Development

Throughout the development process, a main issue was the balance between innovation height and economical and technical realisability. A company with a narrow market, such as Ascom, has fewer degrees of freedom than a large consumer product company. Still, trends are set, realised and made evident to the general public by these companies. As the concept development proceeded, refusals were made sometimes due to economical issues, sometimes due to usable and innovative disadvantages.

7.1.3.3. Evaluation

As the plan was set for the thesis, the evaluation of the final concept was scheduled to mid-July. Due to vacations it was though impossible to involve nurses in actual user tests, and thus the expert evaluation method Cognitive Walkthrough was chosen. To increase the validity of the evaluation, it was made by a third party; a person familiar with the project and educated in usability.

Out of the three parts of usability; effectiveness, efficiency and satisfaction a CW only addresses efficiency. The other two parts will be discussed in the discussion of the final result, below.

7.2. Results

7.2.1. Use System Analysis

Below, the problem areas are discussed one by one.

The amount of alarms and the alarm fatigue was present at the wards, a fact that was verified in literature. The nurses acted on a remarkably low amount of the physiological alarms, either due to fatigue, experience that most of them are false or a combination of them both. It is though hard for an observer to determine exactly when the nurse notice the alarm and draws the conclusion that it does not need to be acted at and when (s)he does not react at all. Furthermore it is difficult to say how well founded a decision not to act is; if it is just due to extent of false-positive alarms or if it is based on knowledge about that particular patients current health status. Once again, it should be pointed out that the alarms presented in the alarm figures are not the actual amount of alarms present at the wards, but the alarms within earshot of the nurse. One noticeable source of error is also the alarm fatigue striking the shadow during the observations.

The extensive walking and the need of the members in a nursing pair to find and

communicate with each other was a source of conflicting results. Some nurses verified that they did search for each other a lot in the nursing pairs and on the interview question of desired information, several answers dealt with location of other nurses. However, on the question if the nurses found it problematic not to be able to locate each other in an efficient way, they all answered negative. The mismatch of findings were analysed and explained in the way that a time, efficiency and fatigue related problem does exist within location of other nurses. The nurses' denial is thought to be result of the relative short time and length of walking they in each occasion and their knowledge (and dislike) of the existing solutions: calling each other at pagers or telephones or showing their location by nurse presence.

The shortcomings of nurse call and nurse presence were discussed and confirmed by the head of product development of Ascom teleCARE. He gave further light to the issue by explaining the strong tradition and conservatism in technical solutions within healthcare. There is a fear from hospital management, that a change might lead to loss of safety, resulting in lack of enterprise in new solutions. This explanation is probably verified by the fact that nurse call systems from different manufacturers have almost identical functional, even though it is not of ultimate efficiency.

The reason for the nurses' strong dislike against telephones stems from the amount and relative unimportance of the incoming calls. Answering these calls is however a necessary part of the nurse's work. It is a difficult task to develop a satisfying product when it is insistently disliked for its very purpose.

A number of issues that were observed and noticed, fall outside of the scope of this project and are thus not brought up in this report. One of those was the co-operative atmosphere between nurses and physicians. A frustration from the nurses against physicians was at noticed at several occasions during the observational research. Unwillingness to contact physicians regarding medical issues and feelings of being used, judged and unseriously taken were observed. This is not likely to be changed with a technical product, but is mentioned here shortly as a point worth noticing.

7.2.2. Final Concept

The final concept, MYco is a communication platform, in which several of the observed problems are addressed and room is left for further development of functionality. One reason for the choice of a evolvable platform is the difficulty in adapting the product to other technology at the hospitals. As being a communication tool, MYco solely redirects information to a certain target; it is not able to create the information itself. Thus, compatibility with the existing technological systems at the hospital is necessary and must be adapted to the functionality, brand and model of each specific system.

Another issue, concerning the more advanced functionality of MYco is whether the product is connected to a certain person or a certain function in work. Functions as for example email and work schedules need to be connected to a certain person, raising the question about whether each and everyone should have their own personal

MYco, or if there should be some kind of log in system.

A vital point of discussion concerns the usability of MYco. It was partially evaluated with the CW addressing efficiency aspects, but leaving out effectiveness and satisfaction for discussion.

There is a paradox between effectiveness and efficiency in this case. The nurses do need portable information to be able to perform good and safe care. They need to have access to identification numbers, medicine ordinations etcetera on the site of action. Effectiveness of a communication tool would thus be a product that could offer this functionality. However, extended functionality of a mobile device such implies more demanding interaction, decreasing the efficiency of the product. A less user-friendly product is more likely not to be used or to be used with limited functionality, decreasing effectiveness. This difficulty was central in the development process and an attempt of addressing it was made by the interaction principles of sleeping technology and the two layers of interaction *simplicity* and *possibilities*, allowing the nurse to be in control of the time, place and situation for more advanced interaction.

As for the third part of usability, satisfaction, concerning the subjective experience of the use and visual appearance of the product, it is hard to discuss theoretically. The intention of the design has not been to create a product that the user should get a passionate emotional relationship with, as is the case with many mobile phones for the consumer market. Yet, it should evoke a sober feeling of content and trust, when used.

Ultimately some detail solutions will be discussed:

The functionality of nurse alert limits the possibility of locating a certain nurse to one person only: the co-worker(s) in the nursing team. The possibility of everyone to see the location of a nurse, as in today's nurse presence system, will then disappear and a reservation is made regarding the fact that there might negative consequences, not discovered in this project. However, as nurse presence is not extensively used in today's care that risk is probably rather small.

There are some concerns regarding the function where vital parameters can be stored and viewed. As it is today, nurses have many different sites where they need to document parameters; formularies, whiteboards, paper documents and the medical record. It is important that MYco does not end up being just one more place to write parameters, but may provide increased quality by the graphical overview or by compatibility with e.g. the medical record. In the last case, modifications ought to be made for the different medical record systems available on the market.

It is important that the modality for call signals can be modified. A system based on sensors, sensing the surrounding circumstances and adapting the modality without involving the user, was chosen. The choice was based on the principle of calm technology, where technical products blend into their context adapting themselves with almost empathic skills. If not accurately adjusted, such auto-settings are possible sources of irritation. Still, the potential of an interaction where the device simply needs to be put away on a table in a sensitive situation, understanding by itself that it

should not disturb, is striking. The alternative way of adding manual adjustments for sound and vibration is perhaps more safe. Nonetheless, that as well constitutes a potential risk; if vibration and sound both would be left turned off and the device in a position out of sight, vital alarms might be missed.

7.3. Recommendations

Recommendations for further work concerns primarily evaluation of the final concept. A proper usability test, including real users ought to be made. Efficiency should be further evaluated through a number of tasks performed by the users. Learnability and experienced user performance should be evaluated in these tasks, rather than guessability, implying that some sort of education should forego the test. Satisfaction should be evaluated through interviews or questionnaires where the user may give their opinion of the product. The last part of usability: effectiveness, is harder to evaluate at such an early stage of product development since it needs to be tested in a real context. However, further discussions regarding desired functionality, involving users and hospital management is a first step.

As for the continued detail development, it is suggested to further investigate the possibilities of sensors and calm technology. Innovative and intuitive ways of handling the product is a powerful way to user satisfaction and exceptional positioning among competitors.

8. Conclusion

This chapter concludes the final outcome of the project and is divided according to the two project phases.

The research question to be answered during this master thesis was:

How can the information flow be rationalised to give the nurse more time and energy for the patient?

8.1. Phase I: Use System Analysis

The research question was addressed from an analytical point of view in a use system analysis, resulting in the conclusion below.

The information flow can be rationalised by enhancing the natural communication ways in the nurse's daily work through

- structural rationalisation of work procedures
- minimisation of information overload
- targeted information
- efficient use of well-adapted information technology

8.2. Phase II: Concept development

The research question was further addressed from a synthetically point of view with the specific aim of developing a technological communication tool, resulting in the conclusion below.

The information flow can be rationalised by a technological communication tool if

- it enhances the natural communication ways in the nurse's daily work through the factors stated in section 8.1.
- it is developed according to the principles of user-centred design
- it has a high degree of usability
- it is unobtrusive and well-adapted to its context of use

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Interview questions

1.Do you work with patient-centred care?
2.What works good and what works bad with patient-centred care?
3.What stresses you the most in your work?
4.Name one thing that you would like to do more of and one thing that you would like to do less of!
5.Does it ever happen that you stand in a patient room and miss information or objects and need to go and fetch anything of that?
6.If you had a person constantly at your side that knew everything, what would you then ask about?

Appendix B

Focus Areas

Specific problems

***1) Alarm fatigue** Takes energy from the patient care. Patient security risk*

- Alarm fatigue
  - What is the problem with the problem: Alarm fatigue
  - Does the problem exist: Yes
  - Why does it occur: Too many audiable alarms
  - What are the consequences: Risk of human lives
  - How often does the problem occur: Almost every minute
  - Do all have the same problem: To some extent, mostly those with heart monitoring

***2) Information handling in medicine distrubtion** Takes time from patient care. Patient security risk*

- Medicine distrubution
  - What is the problem with the problem: Difficulties in receiving the right information about the medicine and patient
  - Does the problem exist: Yes to some extent: the information sources does not cooperate but the nurses compensate with careful procedures
  - Why does it occur: Laptops that are not working, doctors that have bad handwriting or do not write, too many medication lists, lack of information sources at the right time at the right place
  - What are the consequences: The patient might get the wrong medicine
  - How often does the problem occur: 3 times/day
  - Do all have the same problem: Yes but in various ways

***3) Walking with information** Takes time and energy from patient care*

- Keeping information in the head
  - What is the problem with the problem: Information has to be kept in the head due to that it is received at the wrong time or place
  - Does the problem exist: Yes
  - Why does it occur: Nurses get information at one place and has to walk to a computer or a folder to write it down. Nurses are interrupted by patients, phone calls or other staff while doing something
  - What are the consequences: Essential information might get lost
  - How often does the problem occur: Every day
  - Do all have the same problem: Yes
- Walking a lot
  - What is the problem with the problem: They move, not only between patient rooms but to get things and information
  - Does the problem exist: Oyes
  - Why does it occur: Objects are not kept where they are used. Information is not kept where it is used
  - What are the consequences: Time and energy consumption
  - How often does the problem occur: All the time
  - Do all have the same problem: Yes

***-) Task interruption** Takes time from patient care*

- Phonecalls
  - What is the problem with the problem: The nurse is constantly interrupted in her tasks
  - Does the problem exist: Yes
  - Why does it occur: The phone rings and the nurse has to answer in the middle of everything

    - What are the consequences: She might forget information and the patient care gets interrupted
    - How often does the problem occur: It differs with the time of the day and whether she has the ward phone or not
    - Do all have the same problem: To some extent, but it works considerably better when a coordinator distributes the phonecalls

4) Unused function: nurse presence *Takes time from patient care*

- Presence
    - What is the problem with the problem: The nurses do not put themselves as present when they are in a room
    - Does the problem exist: Yes
    - Why does it occur: They don't want to forget to log out and cause an alarm when the patient calls, making everyone run.
    - What are the consequences: It is harder to find each other and to determine if someone is in a room doing something, causing automatic alarms.
    - How often does the problem occur: Depends on the ward, the person and the situation. From sometimes to always
    - Do all have the same problem: Yes, but they treat it in different ways. Some intending to put presence, some not at all.

-) Changing between physical and digital information sources *Specific problem. Takes time from patient care*

- Documentation
    - What is the problem with the problem: It takes time to move information from physical to digital form and back again and it is difficult to find written information since it exists in so many different forms in so many different places.
    - Does the problem exist: Yes
    - Why does it occur: Information exists in many different forms, both analog and digital. The digital is more for storing, the physical for working.
    - What are the consequences: Documentation consumes time and there are risks for lost information
    - How often does the problem occur: Daily
    - Do all have the same problem: Yes but in various forms, since digital information is implemented to various extent

6) Inefficient information channel from patient *Takes time from patient care Patient security risk*

- To call for help without being able to say what you want
    - What is the problem with the problem: It is not possible to tell how important a patient call is.
    - Does the problem exist: Yes
    - Why does it occur: The patient has just one way to call for attention: the call button
    - What are the consequences: Prioritation is impossible for the nurse, demanding her to put everything as top priority
    - How often does the problem occur: Every time a patient calls
    - Do all have the same problem: Yes

****7) Exchange of information with mesosystem*** *Takes time from patient care*

- X-ray
    - What is the problem with the problem: Walking with written information and receiving answers without notice
    - Does the problem exist: Oyes
    - Why does it occur: Papers are scanned and walked with, there is no way to notify the nurse about an answer
    - What are the consequences: The nurse takes time from the patient care to walk with computer written information and takes time and energy remember and check for the answer
    - How often does the problem occur: Every day
    - Do all have the same problem: Yes

- Lab
    - What is the problem with the problem: Same as with x-ray but for answers only
    - Does the problem exist:
    - Why does it occur:
    - What are the consequences:
    - How often does the problem occur:
    - Do all have the same problem:

General problems

8) Fear of technology *Takes time and energy from patient care. Patient security risk*

- Fear of technology
    - What is the problem with the problem: Fear of technology
    - Does the problem exist: Yes
    - Why does it occur: Nurses are unused to technology and believe that they do not cope
    - What are the consequences: They do not use the present technology or use it in a non-efficient way
    - How often does the problem occur: Every day
    - Do all have the same problem: No it differs between individual nurses as well as with the general atmosphere at the ward

-) Interprofessional collaboration *Takes energy from patient care*

- Not liking the doctor that much
    - What is the problem with the problem: Collaboration with doctors is not running smoothly
    - Does the problem exist: According to literature and some indications, yes
    - Why does it occur: There is a "we and them" feeling among the nurses, how the doctors consider the problem is not studied
    - What are the consequences: Avoiding or minimising communication down to the minimum necessity which could lead to worst patient care
    - How often does the problem occur: In case of existent, every day during rounds, otherwise every now and then when a problem occurs.
    - Do all have the same problem: No it depends on personality of nurse and doctor and possibly also by self confidence, strength and knowledge in the nurse
- The patient who fell between the chairs
    - What is the problem with the problem: Doctors and nurses did not communicate with eachother about what they had done and should do.
    - Does the problem exist: Yes apparently
    - Why does it occur: None saw the whole picture. The tasks were made but as separate pieces, without handing over information to the next person
    - What are the consequences: A patient was not seen
    - How often does the problem occur: No information
    - Do all have the same problem: No information

Specific facts

-) Portable information storage *Specific fact.*

- The to-do list
    - What is the problem with the problem: The nurse has a portable information source with patient information and upcoming tasks
    - Does the problem exist: No, it is just a fact
    - Why does it occur: She is constantly moving and does not have access to the patient journal(system). She has a lot of various tasks to keep in mind
    - What are the consequences: She has her own portable way to remember information
    - How often does the problem occur: The nurse makes a list every day

- Do all have the same problem: Yes

-) Organisation of work in nursing pairs

- Work in pairs
  - What is the problem with the problem: Two persons collaborate on the same patients with somewhat, but not totally overlapping tasks
  - Does the problem exist: It is a fact but not always a problem
  - Why does it occur: Patient-centred care
  - What are the consequences: The nurse can do more caring tasks. Problems in dividing the work, doing everything but not twice.
  - How often does the problem occur: They always work like that but cooperate better or worse depending on personality
  - Do all have the same problem: No, some like it, some do not

General facts

9) Emotional labour

- Cooperation ways
  - What is the problem with the problem: Nurses build their collaboration on implicit, emotional labour.
  - Does the problem exist: No, it is just a fact
  - Why does it occur: Emotional labour
  - What are the consequences: They prefer face to face interaction or just looking at the person, determining themselves whether they can disturb them or not. When the personal chemistry does not work, the performance decreases
  - How often does the problem occur: Always
  - Do all have the same problem: More or less, depending on personal
- The nursing atmosphere
  - What is the problem with the problem: The nurses try to create a calm, quite and nursing atmosphere but the technology works against them
  - Does the problem exist: Yes, how much depends on the condition and personalities of the patients.
  - Why does it occur: Telephones ring, alarms sounds
  - What are the consequences: Nurses do not want to answer the phone, or have a ringing sound with them all the time
  - How often does the problem occur: Many times per day
  - Do all have the same problem: No, it depends on the type of ward, the atmosphere and the type of technology

- Not having to call eachother but searching a lot – the contradiction
  - What is the problem with the problem:
  - Does the problem exist:
  - Why does it occur:
  - What are the consequences:
  - How often does the problem occur:
  - Do all have the same problem:

Ward A

Specialisation	Neonatalogy
Number of patients	16
Diagnoses	• premature babies born from week 27 • sick fully developed babies
Location	middle sized city
Shadowed nurse	Nurse Anna working loosely in pair with NA Aida, together caring for 3 patients
Work division	nursing pairs dividing the patients among them according to nursing load and who they worked with before
Medicine technical equipment	• incubators • physiological monitors with telemetry • respirator, drainage and other intensive care equipment
Communication tools	• Ascom pagers for telemetry alarms and alarms from delivery ward • patient monitors • BEST patient nurse system • stationary telephones at nurse station • stationary computers at nurse station
Atmosphere	tranquil, mild, motherly

Ward B

Specialisation	Medicine
Number of patients	25
Diagnoses	• cardiac diseases • cancer • COPD • infections
Location	small city
Shadowed nurse	Nurse Bea working in pair with NA Bibi, together caring for 8 patients
Work division	Nursing pairs with patients divided into 3 groups
Medicine technical equipment	• 5 physiological monitors with telemetry • other general care equipment
Communication tools	• Ascom pagers for telemetry alarm (not used) • patient monitor • BEST nurse call system • portable telephone, answered by coordinator • stationary telephones at nurse station • stationary computers at nurse station • laptop at medicine trolley
Atmosphere	animated, peppy, jokey

Ward C

Specialisation	Medicine - endocrinology
Number of patients	14

Diagnoses	• diabetes • kidney diseases • general medicine related diseases
Location	small city
Shadowed nurse	Nurse Cecilia caring for 6 patients, sharing one NA that cares for all patients
Work division	Nursing pairs with patients divided into 2 groups
Medicine technical equipment	• general care equipment
Communication tools	• BEST nurse call system • portable telephones, calls filtered by coordinator • stationary computers at nurse station • laptop at medicine trolley (not functioning)
Atmosphere	calm, neighbourly, feminine

Ward D

Specialisation	Transplantation
Number of patients	19 (+18 at the twin ward)
Diagnoses	• kidney transplantation aftercare • liver transplantation pre- and aftercare • lung transplantation pre- and aftercare • liver surgery • multi-transplantation pre- and aftercare • (heart transplantation at twin ward)
Location	big city
Shadowed nurse	Nurse Doris working in pair with NA Dina, together caring for 7 patients
Work division	3 modules including a nursing pair, 6 patients and a nurse station at each (+3 modules at twin ward)
Medicine technical equipment	• general care equipment
Communication tools	• Ascom pager for nurse call • Ascom nurse call system • patient monitor • Ascom portable telephones, filtered by coordinator
Atmosphere	trendy, business, hightech

Ward E

Specialisation	Coronary care
Number of patients	20
Diagnoses	• heart attack • arrhythmia • cardiac failure
Location	middle sized city
Work division	Nursing trios with consisting of at least one nurse
Medicine technical equipment	• physiological monitor with telemetry • other cardiac care equipment

Communication tools	• Ascom pagers for telemetry and ambulance call • patient monitor • BEST nurse call system • portable telephones, filtered by coordinator

Ward F

Specialisation	Cardiopulmonary emergency
Number of patients	21
Diagnoses	• cardiopulmonary diseases • pneumonia • heart attack • COPD
Location	middle sized city
Work division	nursing pairs
Medicine technical equipment	• physiological monitor with telemetry • ECG • general care equipment
Communication tools	• Ascom pagers for telemetry • patient monitor • BEST nurse call system • portable telephone filtered by one nurse

Appendix D

Brainstorming – set-up

Introduction

The facilitator introduces the participants about

- The main scope of the project
- The problem areas
- The aim of the concept: To rationalise of the information flow around the nurse to give space for increased patient focus.

The association game

The facilitator starts by saying a word and the next person in turn is then going to say the first word that pops up in the head. The game contiues among the participants for a few rounds.

Discussion

Three terms are discussed. The facilitator shows a relevent example of two products or situations; one that expresses and one that does not express every term. The participants are asked if they agree or not, and why. The themes are:

- Mobility
- Unobtrusiveness
- Technology for people that do not like technology

Idea generation

The following situations are presented to the participants that get a few minutes to generate ideas individually. They then read them out loud in front of each other, while the facilitator writes them down on notes.

1. How can Linda receive calls and alarms without anyone noticing?
2. How can Linda determine which one of three patient calls that is the most important, without leaving the room she is currently in?
3. How can Anki check her Facebook without getting caught?
4. How can Linda ask for help from a colleague at the same time as she is stopping a sudden bleeding on a patient?
5. How can Anki choose the least exhausting of the alarms, calls and tasks that she should do at that moment?
6. How can Linda check a lab answer without reading any text?

Further concept development

The participants pair up and are asked to pick a note from the idea generation. They get 20 minutes to develop the note (or more notes, if they have time). They may develop that specific idea in detail or make a more holisitic concept.

Unobtrusiveness

- It depends on ones mood if it is obtrusive
- If you have to pay they are obtrusive
- They sit down, resting, that looks unobtrusive.
- They are a bit nerdy, I don't have to be afraid. Therefore it is not obtrusive
- If they would make too much noise I would dare to tell them to stop
- They are obtrusive: they sound a lot!
- If they sit in the wrong place, they do not fit and then they are obtrusive.

- He doesn't want to cut it off
- His body language makes him obtrusive
- The frog perspective makes him larger and more obtrusive
- He looks like a predator, like he's going to bite
- The contrasts in the picture makes it obtrusive
- He is mostly in the wrong place but if he sould be on a beach party he would not be obtrusive
- He is happy. It's impossible to be very happy and not obtrusive

- Unobtrusiveness is fitting into the environment.
- Unobtrusiveness is often anonymous. What makes a product unique, but unobtrusive?
- Find something that fits into the environment, but is visible in a comfortable way.

Mobility

- It is mobile in itself
- It is smaller than the computer
- You can put it in your pocket
- It seems cheaper than a computer, less exlusive
- Always ready to be brought along
- Cosy materials. I rather bring a ball than a cube.

- It’s mobile within a certain radius
- IT depends on how strong you are
- You always have to bing something extra, a cord for example
- You have to pack it down into a bag
- I’m more afraid of breaking it than with a celphone. TI don’t bring it on an after work if it would be stolen.
- It’s annoying to carry around to much information
- Difficult to carry

- You can walk and talk but you can’t walk and check your mail.

Technology for those who don’t like technology

- Cars haven’t been that technical traditionally
- It’s just to drive and put on the radio, it’s simple
- It’s supposed to be simple and if it’s not, if you run into problems it’s okey to call for help immediately
- You get an education!
- It’s a common thing to learn to drive. It doesn’t differentiate people according to interest
- It’s a motorical knowledge to drive
- It’s not either black or white: it’s possible to drive on the wrong gear.
- Car driving works the same, independent car brand
- It is the same task every time
- If you have to attach a wagon it gets complicated as the dvd player.

- The need can be postponed until you get help
- You can do everything and the basic task is not simple
- There is a big difference between aim and execution
- You associate it with the teacher that failed putting it on during class
- Install is the problem
- It’s embarassing not to know
- It’s like an iq test, you have to figure it out yourself
- It’s theoretical knowledge
- It’s either right, than it works, or wrong than it doesn’t work at all
- The fear of technology comes from that you feel evaluated and you don’t want to do wrong.
- You have to connect the product to so much other things and it’s not compatible

Appendix G

Sketches from idea development

Demands sorted by category

Demands	Note
Calls and alarms	
Receive and alert about alarms	without disturbing the nearest surroundings
Provide detailed information about alarms	with minimum handling
Allow silencing of alarm	with remaining reminder
Receive and alert about patient calls	without disturbing the nearest surroundings
Provide information about location of patient call	with minimum handling
Allow silencing of patient call	with remaining reminder
Receive and alert about incoming phone calls	without disturbing the nearest surroundings
Allow denial of incoming phone call	
Nurse cooperation	
Allow co-nurse poke	
Allow identification of co-nurse location	
Receive nurse poke	
Send current location	when requested through nurse poke
Allow denial of nurse poke	
Allow nurse alarm	major alarm to all colleuges
Allow synchronisation within nursing pairs	
Application management	
Allow text input	
Allow overview and searching of information	among an within applications
Provide notifications of external events	
Administration	
Allow assignment of patients	in an intuitive way
Store in charger	
Physical handling	
Attach on body	
Handle basic functions with simple moves	
Emotional aspects	
Provide interaction according to calm technology	
Avoid technologic expression	
Provide high learnability	
Minimise obtrusiveness	

Demands sorted by ranking

Demands	Note
Receive and alert about alarms	without disturbing the nearest surroundings
Receive and alert about patient c	without disturbing the nearest surroundings
Provide information about locatic	with minimum handling
Attach on body	
Minimise obtrusiveness	
Allow silencing of alarm	with remaining reminder
Allow nurse alarm	major alarm to all colleuges
Allow silencing of patient call	with remaining reminder
Allow denial of incoming phone call	
Provide detailed information abo	with minimum handling
Allow assignment of patients	in an intuitive way
Handle basic functions with simple moves	
Allow denial of incoming phone call	
Provide interaction according to calm technology	
Avoid technologic expression	
Allow identification of co-nurse location	
Provide notifications of external events	
Send current location	when requested through nurse poke
Allow synchronisation within nursing pairs	
Allow co-nurse poke	
Receive nurse poke	
Allow denial of nurse poke	
Allow text input	
Allow overview and searching of	among an within applications
Store in charger	

Demands	Note	Triangular matrix																									Number of votes
Calls and alarms		3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	20	21	22	24	25	27	28	30	31	32	33	
Receive and alert about alarms	without disturbing the nearest surroundings		3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	25
Provide detailed information about alarms	with minimum handling			5	6	7	4	4	4	4	4	4	4	4	17	4	4	4	4	24	4	27	28	4	4	32	33	15
Allow silencing of alarm	with remaining reminder				6	7	5	5	5	5	5	5	5	5	17	5	5	5	5	5	5	5	5	5	5	5	33	20
Receive and alert about patient calls	without disturbing the nearest surroundings					6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	24
Provide information about location of patient call	with minimum handling						7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	23
Allow silencing of patient call	with remaining reminder							8	8	8	8	8	8	8	17	8	8	8	8	24	8	27	8	8	8	8	33	16
Receive and alert about incoming phone calls	without disturbing the nearest surroundings								9	9	9	9	9	9	17	9	9	9	9	24	9	27	28	9	9	32	33	13
Allow denial of incoming phone call										10	10	10	10	10	10	10	10	10	10	10	10	27	10	10	10	10	33	16
Nurse cooperation																												
Allow co-nurse poke											13	*	15	12	17	18	12	12	22	24	12	27	12	12	31	32	33	7
Allow identification of co-nurse location												13	*	13	17	13	13	13	22	24	13	27	28	13	13	13	33	11
Receive nurse poke													15	14	17	18	14	14	22	24	14	27	28	14	14	14	33	7
Send current location	when requested through nurse poke													15	17	18	15	15	22	24	15	27	28	15	15	15	33	9
Allow denial of nurse poke															17	18	16	16	22	24	16	27	28	30	31	32	33	3
Allow nurse alarm	major alarm to all colleuges															17	17	17	17	17	17	27	28	17	17	17	17	19
Allow synchronisation within nursing pairs																	18	18	22	24	18	27	18	30	31	32	33	8
Application management																												
Allow text input																		20	22	24	20	27	28	30	31	32	33	2
Allow overview and searching of information	among an within applications																		22	24	25	27	28	30	31	32	33	0
Provide notifications of external events																				24	22	27	28	30	22	32	33	10
Administration																												
Allow assignment of patients	in an intuitive way																				24	27	28	30	24	32	33	14
Store in charger																						27	28	30	31	32	33	0
Physical handling																												
Attach on body																							27	27	27	27	33	20
Handle basic functions with simple moves																								30	28	32	33	13
Emotional aspects																												
Provide interaction according to calm technology																									30	30	30	11
Avoid technologic expression																										32	33	12
Provide high learnability																											33	20
Minimise obtrusiveness																												