Conceptual design of a large screen collaborative system through analysis of coordination mechanisms at hospital staff meetings

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ABSTRACT
This paper presents a conceptual design of a CSCW system utilizing a combination of a large screen and a PDA based interfaces within the setting of a hospital ward. The design is based on an analysis of coordination mechanisms as identified through an empirical study of staff meetings among nurses at a surgical ward in a medium sized Danish hospital. A brief review of the current body of research into the field of CSCW and in particular the support of coordination mechanisms in collaborative systems is presented as a prelude to the empirical findings and the conceptual design. The design was evaluated through a focus group interview with two nurses using a paper prototype and scenarios. The evaluation confirms the key findings extracted from the empirical data and allows us to present a redesign of the paper prototype.

1. INTRODUCTION
The introduction of electronic patient records at the hospitals may have an impact on the work habits of the staff and require a change in order to accommodate the introduction of new technology. There is already a large amount of collaborative practices employed in the hospital service, and with the removal of the paper records the staff might be required to adopt new ways of sharing and accessing information about patients. At the same time the introduction of these new technologies offers new possibilities for supporting work performed at the hospitals. As records becomes electronically available infinite copies of a particular record exist and problems with missing records because someone else is using it or has forgotten to hand it in after the use is terminated. With access to the electronic records new ways of use may become possible along with new ways of presenting the information. Such information may be presented e.g. through a large computer screen like on a blackboard which could provide a tool for reviewing the patient records but also support collaboration between parties or users may have access to the information at any place through mobile devices. To investigate these possible advantages of large screens to support collaboration within the hospital domain we have proposed the following research question.

How can we identify relevant collaborative practices within a given domain, to assert possible uses of large screen collaboration?

This article presents a conceptual design of a system utilizing large screens for collaboration, and the empirical data on which this design is based. A brief introduction to coordination mechanisms and an overview of ways to support these is presented. This leads us to an initial design which is reviewed through a focus group interview. This review is discussed, and the changes suggested are used to present specifications for a redesign.

2. COORDINATION MECHANISMS
In order to understand how the nurses collaborate we have applied the theories of coordination mechanisms [9] to our collected data. In section 4.3 we will clarify which coordination mechanisms the nurse's use during their morning meeting and further how we have modelled these mechanisms as computational coordination mechanisms.

Coordination mechanisms are a way to understand the processes which occur in an organization when a group of people try to collaborate in order to solve problems within their field of work. [9] Schmidt and Simone state that coordination mechanisms are constituted through two terms; cooperative work and articulation work. In order to understand coordination mechanisms we must first understand both of these terms. Schmidt and Simone state that cooperative work is defined as [9]:

> *"Cooperative Work is constituted by the interdependence of multiple actors who, in their individual activities, in changing the state of their individual field of work, also changes the state of the field of work of others and who thus interacts through changing the state of the common field of work."*

This states that cooperative work exists when different independent actors within the same field of work changes the state of work for other actors by changing the state of their own field of work. An example could be an assembly line where one worker receives a new set to assemble once he or she has finished the set is sent on to the next person in line which then applies the casing to the product and on to the next which places the product in a box to be shipped. The actions of the first, finishing the set, affects the next worker in line as he or she now has to apply the casing to the product. Again this worker affects the next in line and so on.

Articulation work is defined by Schmidt and Simone as:

> *"..the orderly accomplishment of cooperative work …"*

According to this definition articulation work is the attempts to solve the coordination, scheduling and integrating activities which arise from the independent actions performed by one actor within a work domain which affect others within that domain.

Gerson and Star [5] have provided another definition of articulation:

> *"Articulation consists of all the tasks involved in assembling, scheduling, monitoring, and coordinating all of the steps necessary to complete a production task."*

This definition focuses on the task involved with the completion of a production task, but we believe that it can also be applied to the processes which occur during a meeting where task are scheduled and coordinated, as is the case at the morning meetings in our case. One way of describing articulation is as the coordinative overhead introduced when distinct actors have to coordinate their efforts on a joint task. An example of articulation could be the meetings required to coordinate the efforts of individual persons needed to produce a paper done in collaboration between different actors. The term coordination is preferred throughout this paper to describe articulation work.

3. SUPPORTING COORDINATION MECHANISMS

There have been many attempts at solving the problems associated with collaboration on large screens and the support of coordination mechanisms [2]. This section deals with some of the ways of supporting coordination mechanisms that exist in the current body of research.

3.1 Collaborative systems

The concept of coordination mechanisms are not necessarily an explicit topic of research for the literature presented here, but all systems employ some form of coordination mechanisms as is generally true for most collaborative systems. Here we will present some of the systems which have experimented with collaborative systems and how they have supported coordination mechanisms. The solutions presented here have been use a grounding inspiration on how to support collaboration.

3.1.1 Colab

The system presented by Stefik et al. in [11] is designed for small workgroups situated in front of a large screen display and all connected by a computer network. Each user can use the workstation as personal space but also as a remote control for elements on the large screen through the workstation and thereby share work and ideas with the rest of the team. The researchers state that:

> *"A fundamental requirement for meeting tools is that they provide a coordinated interface for all participants."*

In this case the fundamental coordination mechanism is inherent in the idea of meeting tools. The act of meeting and collaborating on a subject is in itself a mechanism for coordination between distinct participants. The system allows every user to edit the objects presented with the system. A consequence of this privilege is the possibility of conflicts which can not be always solved by social protocols. To avoid these conflicts the system greys out any object which is being edited by a user on all screens and other users can not manipulate the object while it is being used. This is a feature which supports the coordination mechanisms of a group using the system as other users are oriented towards the actions of one user.

After testing they discovered that in the early sessions of tests that constraining the system to only allow one person to enter text at a time could be a resource for the collaboration as it created a shared focus for the group and constituted a common context. They find that independent writing activities require new ways for the participants to remain oriented of what the others are working on. Their tests showed that work stopped every few minutes because the test subjects lost track of the plan of action and this started a small discussion of where they were and what they should do. So in this particular scenario the mechanism of coordination actually becomes a hindrance because they are not successful supported by the system.

What this means for coordination mechanisms in collaborative system, is a requirement for a new social protocol. In general there is rarely the opportunity to stop work every 5 minutes in order to examine the status of other participants. A solution is to introduce some kind of certainty that everyone is doing their part.

3.1.2 MMM

An architecture for the design of user-interfaces for collaborative single devices was presented by Bier and Freeman [1]. They wanted to investigate if multiple input devices for a single display are convenient when users are collaborating. In their research they address four problems in user interface design.

1. How can an input device be quickly registered with a user?
2. How should the screen be managed so that collaboration is practical in limited space?
3. How can the system direct feedback to the right user without disturbing others?
4. How can users engage in separate tasks without interfering with each other?

To answer these four questions they have created an interface architecture composed of three visible components: Home areas, Editors and Menus. Each user can manipulate every editor in the system and several users can work with the same editor at the same time. The entire system is composed of windows which can be embedded into each other and they can be placed anywhere on the interface. In this particular system the coordination mechanisms are tied into the ad hoc sharing of continual usage statistic for the individuals using the system, in particular the coordination efforts of knowing what someone is doing is solved by the introduction of a shared workspace.

3.1.3 Single Display Privacyware

Shoemaker and Inkpen [10] designed their system to allow users to view information through a pair of glasses which then filters the input from the system and only presents the user with certain frames which contain the private information for this user.

Through their tests they find that the test subjects who experimented with the private version performed slightly better in the tests than the test subjects who were experimenting with the public version. In contrast to these results the test subjects expressed preference for the public display. They appreciated being able to see the other user's cursor so that they knew what their partner was working on. This is an experiment with privacy and information occlusion of private information. Even though their system seemed to support the users work, they find that the view of the other users was preferred. This can be seen as a consequence of a lack of support for the user's coordination mechanisms. The users were unable to maintain a coherent and shared view of the work being performed.

3.1.4 Dynamo

Dynamo [6] allows users to carve out an area on a screen which they can work in. This is strictly a personal space and no other user can manipulate it. They can also leave an invitation to a carved space for another user in the form of a small key addressed for the specific user. The owner of a carved space can invite others to the space and thereby granting them the same rights to manipulate objects in the carved space. Information can also just be shared in the public allowing everyone to manage it.

In their first prototype the distribution of objects on the display is governed by purely by social protocols. Through their evaluation of the system they discover that the completely *"free for all"* spaces have a downside. Users can intrude upon other users and take over their working area. As a consequence they implement a hybrid there the carved spaces mark areas for a user to work without interference. Overlaps can still occur within a region, public or private, but this makes it more manageable.

Through their tests the researchers also found that new social protocols were quickly established between the participants which allowed issues such as overlaps to be resolved quickly, these social protocols acts as "constraints" on the actual coordination mechanism employed by the system, which in this case is the system itself.

3.1.5 Caretta

The Caretta system [13] displays a shared space on a sensing board where personal space is displayed on each users individual PDA's. In personal mode each user can manipulate objects on their own PDA without interference from the others and these changes are not reflected on the shared space. In public mode their PDA's are linked to the shared space and every change to it changes the state of the PDA. In this system configuration the board becomes a method of coordination for the individual users, and the PDA´ acts as a storage device for this configuration.

When users are working in personal space they may not be aware of what is happening on the shared space. To prevent this from hampering the progress of the work being performed the researchers have implemented a voting system. Whenever a change is proposed to the group a vote is required for it to be accepted. If more than half the people vote for it the change is accepted and applied to the shared space. In effect, the effort of coordination becomes a democratic process where votes are cast in accordance with ones expectations for the continued work.

3.1.6 SenseWeb

The SenseWeb [7] system allows users to browse and organise a collection of pictures on a large screen with the use of their hands. The users can manipulate every picture but the researchers rely on social protocols in order to avoid conflicts.

The advantages of this system are that:

> *"the users can work in parallel or synchronously to interchange opinions, thus speeding up the selection process."*
>
> *"They don't need to worry about when they can directly manipulate the images or not."*

Their tests of the system show that most of the test subjects prefer the prototype where they are able to interact with the system at the same time and the comparative tests showed that the users using the collaborative system had slightly better completion time. So in this particular case the act of coordination is most successful as a distributed collaborative mean.

3.2 Types of conflict

The systems presented in the preceding section all employ a strategy for determining conflicts in the collaborative efforts. Morris et al. [8] have described these strategies as based on two primary conflict dimensions: Conflict type and Initiative. They have created a matrix shown in Table 1 of the coordination policies which they have proposed as solutions for designers to consider. We have chosen to present the matrix as they present it, thus omitting the sub element part of initiative.

The phrases in each box are the names of the solutions which Morris et al. have proposed in their paper. Each phrase is associated with a conflict type and an initiative. The conflict types are the way the system determines when a user can manipulate an object. The initiative is the level at which manipulation of the system is being performed.

		Conflict type		
		Proactive	**Mixed-initiative**	**Reactive**
Initiative	**Global**	Privileged objects Anytime	Rank	No selections No touches No holding documents Voting
	Whole-Element	Sharing Explicit Dialog	Rank Speed Force	Public Private Duplicate Personalized views Stalemate Tear

Table 1 Strategies based on conflict type

In the article [11] the researchers have chosen the Reactive policy "Public" to handle conflicts when users edit a Whole-element. But when ever a user begins to edit a document this document is locked to the user and its colour is faded to grey thereby creating Private objects thereby using the policy of Sharing.

Bier and Freeman [1] have chosen to give the users equal rights to every object in the system which is equivalent to a "Public" policy as in [11]. But they have implemented some control mechanisms as each user is registered to a colour and a mouse.

Shoemaker and Inkpen [10] have used the "Private" policy by removing private documents form the view of other users. They have also hidden the actions of the users by hiding the mouse curser, but their tests showed that the users preferred it otherwise.

In the Dynamo system [6] employs both the reactive policy "Privacy" and the proactive policy "Sharing". The users can carve a space there they are in complete control, but they may invite other users to this space and thereby granting them equal rights.

The Caretta system [13] uses a "Private" policy by granting each user an explicit private space in the form of the PDA's. But when it is time to make changes to the shared space it requires a vote so they also employ the Voting policy.

SenceWeb [7] is on all accounts “Public”, there are no restraints on what users can do and manipulate. This system relies solely on social protocols to solve conflicts.

All the solutions we have found have been solution to avoid conflict when whole-elements are being manipulated. We have not found papers which describe how users may manipulate global objects.

4. EMPIRICAL STUDY

This section details an empirical study of nurse meetings at a hospital ward. The goal of the study was general domain insight and in particular identification of coordination mechanisms in order to extract design guidelines for a system supporting these meetings. The study was conducted through two observation sessions resulting in three key issues and a corresponding number of design guidelines.

4.1 The hospital ward

The choice of case for our study is led from a research project previously performed in cooperation with the ophthalmology ward at Aalborg Sygehus Syd. This is detailed in [3] After completion of these studies, especially one aspect of the work which we found particularly interesting but had not yet explored, stood left. This was the collaborative aspects of various staff meetings at the ward. In that regard a collaborative system might afford a tangible advantage for the nurses. We reinitiated our contact with the ophthalmology ward and they allowed us to observe two staff meetings at the bed ward of the department.

The bed ward is associated with the ophthalmology ward. This ward has 12 bed places distributed on two single bed rooms, one room with two beds and two rooms with four beds. The ward has patients from the ophthalmology ward as well as patients for the ear, jaw and neck surgical units. The ward handles pre and post op patients and running patient care for these patients.

4.2 Observations of meetings

We were allowed to perform two observations over the cause of two days. Each observation was performed in the morning at 7 am. At each meeting we observed the entire meeting without interrupting but asked clarifying questions when the meeting was concluded. As the patient data and the medical history of patients is defined as confidential information, both by law and common hospital practice, we were not allowed to record any data, besides our own notes, during the meeting.

The meetings takes place in a conference/office room as detailed in Figure 1. The individual nurses are seated around a table where they discuss the care and pending treatment of patients already admitted or scheduled for arrival on the same day. Each morning 3 different groups, each with between 4-8 nurses present, gather separately for these meetings. A nurse is responsible for reading aloud from the VIPS record [4] the description and reviewing process associated with each individual patient. As she reviews these patients, she points out any special care and needs a given patient have. Once a patient has been reviewed their records are placed in a folder for later use. During the review of a patient each nurse in the group writes down keywords related to the care of the patient on her individual worksheet. These sheets are all identical and are distributed to the nurses at the beginning of the meeting. The information noted by the nurse is selected individually, but our observation showed that many of the nurses noted the same data. Some nurses used different colours to note certain information. When asked to clarify this, they explained that each shift had a different colour for writing in the Patient record and on their worksheet they liked to display certain types of special care with different colour for easy reference.

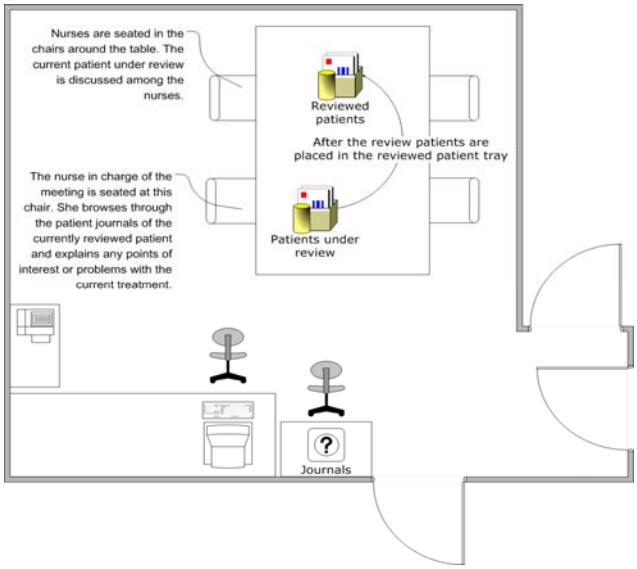

Figure 1: Layout of meeting room

The nurses recorded patients who were fasting and who were up for evaluation as well as patients who needed blood tests with a red pen. Any patients fasting were also marked with a yellow marker. While the patients were being reviewed by one nurse the others asked questions into reasons for specific care or treatment as well as supplied with information they had about the patient in order to provide a detailed picture of each patient’s situation and to establish a common understanding of procedures and treatments. After all patients have been reviewed the tasks of the day is distributed among the nurses according to competences and knowledge of the patients. For example if a nurse had taken care of a patient the day before she was the most likely candidate to care for this patient again because the patient already knew her. Responsibility for handing out medicine is placed apart from the other assignments. As an example one nurse can be selected for giving medicine to every patient at the ward, or it can be distributed among several nurses.

4.3 Coordination mechanisms identified

When analyzing the situation in the meeting room we found that one nurse is reading from the VIPS records in order to provide the group with a common understanding of each patient’s status. If a nurse is unclear about the reason for a treatment or the specifics of a procedure they other nurses try to supply this information. At the end of the meeting they divide the patients amongst them and decide who is to distribute medicine to the patients. All these three actions can be seen as coordination work as they change the state of their individual field of work. The state of the patients is objectified through the artefact the VIPS record and their individual record sheets. The later also holds the division of tasks between the nurses. The treatments and procedures are objectified through both the patient record and their intranet where descriptions of procedures are available.

This can be seen as a coordinative mechanism as they begin their day by articulating a common understanding of the patient status.

They change the state of the field of work by articulating this common understanding. Afterwards their work is very independent and they all contribute to changes in the field of work independently until the next morning. At the meeting they articulate reasons for the treatment given to a patient and discus the procedures for the different treatments. In order to remember information about patients each nurse uses an artefact in the form of a record sheet on which they write keyword related to each patient. The record sheet is divided into a large matrix with patients vertical and notes horizontal. The sheet functions as a way to retain the information. At the end of the meeting they coordinate who is responsible for the different tasks of the day. Again we see that the meetings follow a set of protocols which are intended to ensure a common understanding of the field of work, which we classify as a coordinative protocol and these protocols are objectified through the artefact, the record sheet, and thereby we also classify their morning meetings as a coordinative mechanism.

In general we can classify the work performed by the nurses as cooperative through Schmidt's proposition 1 [9] as the actions they take during their shift may change the state of the patient and thereby change the state of the field of work for the nurse on the next shift. These changes are then articulated through four artefacts; the intranet, their record sheet, the patient record and the VIPS record. These records are means of reducing the complexity of articulation work, as described in Schmidt's proposition 3 [9]. Much of the nurse's work is performed on the basis of formalized procedures and can therefore be perceived as coordinative protocols and the records can be formalized as artefacts objectifying the protocol, thereby their work can be classified as a coordination mechanism [9].

4.4 Key issues

Based on the identified coordination mechanisms and our observations in general we have deduced following key issues regarding the process of a morning meeting at the ward. These are used to decide upon design guidelines for a prototype system.

- Redundancy in coordination
- Lack of access to information for all participants
- Colour encoding

Redundancy in coordination relates to the usage of a distributed coordination tool to maintain coherence in the assigned tasks and the individual responsibilities of the nurses. Currently this is done by each nurse on a piece of paper. This process is not necessarily the most efficient method of maintaining coherence, and is a topic of some potential misunderstanding. As the process is done individually the potential for erroneous registration of tasks and responsibility is also increased.

Lack of access to information for all participants relates to the practice of a single nurse reviewing the paper records by reading aloud. If a misunderstanding or misreading of information occurs at this point in the information processing it propagates to all the nurses present.

Another noticeable usage pattern exists in the colour encoding employed by the nurses. This colour encoding is based on a well established paradigm, where each shift uses a different colour pen to input information. This is used extensively in the search strategy employed by the nurses when reviewing records, and as such is an essential aspect of their work.

4.5 Design guidelines

Based on the principles of coordination mechanisms and the key issues identified in the previous section we propose the following guidelines for the design of a collaborative system employing large screen interaction and hybrid interfaces.

- Support coordinative mechanisms for assigning tasks and responsibility in a centralized way
- Shared information space
- Support colour encoding

The first principle is based on the usage of the current distributed coordination mechanism, the paper sheet containing work tasks etc. and the need to support this essential coordination task. A coordinating single system for keeping track of these tasks and responsibilities seems prudent based on this. This is an attempt to avoid redundancy in coordination and securing the level of coherence.

The principle of a shared information space concerns the issue regarding lack of access to information for all participants. While a single nurse can remain in charge of reviewing the information by reading aloud all participants should have the option to consult a shared view for additional information or repetition of specific parts preventing some potential misunderstanding issues present with the current practice.

As colour is already a traditional way of distinguishing between the times of day certain information is added to the record, the design should support this feature.

Based on these design guidelines we propose a design presented in the following section.

5. Design

We have aimed our design at supporting the nurses during their morning meeting by providing them with a system which supports the coordination mechanisms which they employ during a normal meeting.

5.1 Large screen

The first coordination mechanism which we identified as evident to support is the review of a patients VIPS record. Each VIPS record should be available through the systems access to the EPR system and can therefore be presented on the large screen display. While one nurse still can be in charge of reading the entries aloud the other nurses will now be able to read the instructions on their own while she is reading and thereby removing the chance that the nurse in charge of reading might misunderstand or miss some pieces of information.

The main interface of the large screen is shown in Figure 2. It is possible to rearrange the various windows freely by dragging them to a new location. The individual interface elements are explained in the following.

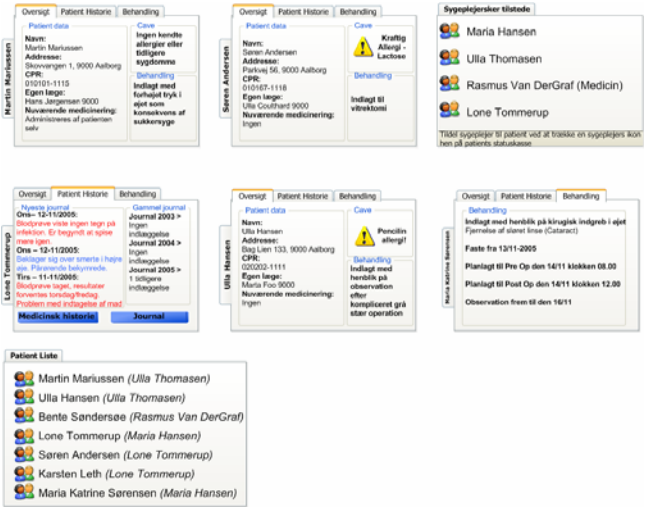

Figure 2 Large screen interface in entirety

Figure 3 shows an interface element representing a specific patient. The tab Overview ("Oversigt"), which is currently active, presents a general overview of the patient, their current treatment and if they have any allergic or medical care needs that are different from the average patient. Each patient awaiting review on a particular meeting is represented on the large screen by a similar tabbed box.

Figure 3 Overview of a specific patient

Normally the nurses are reading from the records as they discuss treatment and admission history, and try to supply each other with information if someone is unclear about procedures or reasons behind the choices of treatment. This is supported by the tabs Patient history ("Patient Historie") shown in Figure 3, and Treatment ("Behandling") shown in figure 4.

The patient history show in Figure 4 shows the latest entries from the VIPS record. Colour encoding is used to distinguish between shifts according to our third design guideline.

Figure 4 History of a specific patient

The Medicine history ("Medicinsk historie") button is a historic overview of which medication the patient has received. The Record ("Journal") button opens the traditional record system to allow a detailed view of all records of the patient. This allows the nurses to easily learn about the reasons behind a choice of treatment and establish their common understanding of the current situation at the ward.

Figure 5 displays a list of pending treatments and the basic premise for admission, such as heightened pressure in the eye. This facilitates an overview of the treatment history and supports a structured planning process. Our system will in combination with the record viewing functions provide the nurses with easy access to information about procedures and treatment history. It is possible to drag interface elements around to facilitate comparison and structuring of associated problems and the like

Figure 5 Treatment of a specific patient

All together the described functionality of the system supports the coordinative protocol of ensuring a common understanding of the field of work, while fulfilling the design guideline of a shared information space.

Figure 6 A list of nurses present

Two lists are present on the interface. One list denoted Patient list ("Patient liste"), contains all patients currently under review with the associated nurse in a parenthesis after the patients name. The other list denoted Nurses present ("Sygeplejersker tilstede"), shown in Figure 6 is a list of nurses present. In this list a special responsibility such as the administration of medicine is denoted in parenthesis after the nurse name.

To assign a nurse to a patient the icon for the given nurse is dragged to a patient. Hereby we support coordinative mechanisms for assigning tasks and responsibility in a centralized way avoiding a great deal of redundancy as the nurses are no longer required to record the relations on their individual sheets of paper.

The entire system is based on interaction and collaboration in front of a single large display. We have envision that the system will support collaboration by allowing each nurse equal rights to interact with the system but tagging them some kind of identification device and allowing the system to display the changes which they make as in [1]. When a nurse begins to edit an object this object is locked to her and others are prevented from editing it as well as in [11]. Thereby we are utilizing the policy "Public" but with the constraint that while being edited an object cannot be edited by another user.

5.2 PDA

By providing the nurses with a PDA each the need for a record sheet where they can write the situation of each patient becomes redundant. The PDA will provide them with a overview of the patients and access to each patients record. The PDA interface will provide a basic quick overview of each patient and the current situation of patients. This overview is combined with the different colour codes which we found to be used in the record and as a coordination mechanism during the meeting. As shown in Figure 7 the PDA version borrows the fundamental display from the large screen version of the system. A basic overview for a given patient is shown, and a drop down dialog shows all available patients. The "Vis på Storskærm" button allows a nurse to "activate" a given patients information on the nearest large screen.

Figure 7: The PDA interface for the system

The PDA's will provide the users with a level of privacy where they can edit the system without other users viewing and will also function as a remote control for the large screen. A function which has been inspired by [13] is the ability to find relevant information on the PDA and then send a request to the system to display this information, without having to disturb anyone interacting with the large screen while searching for the information. Here we utilize the policy "Private".

6. DESIGN EVALUATION

This section presents the method applied for evaluation of our system design, a description of the actual evaluation and concludes with a presentation of our findings through the process.

The evaluation was conducted as a focus group interview participated by two would be users of the system. It was supported by two design artefacts, use scenarios and a paper prototype. The goal of the evaluation was threefold. Firstly it served as a paraphrasing of our observations at the patient care conference meetings deciding to what extent our perception of the work domain matched reality. More specifically we were able to validate the key issues identified through our analysis by discussing them with the nurses. Secondly we wanted to initiate a discussion between the two nurses about our system as a tool for their meetings and its impact on their daily work. This to argue to what extent our applied design guidelines satisfies the key issues. Finally we sought to identify issues regarding specifics in our design.

6.1 Scenarios

To present the envisaged application of our system we created hand drawn scenarios visualizing the system in use. An example of such is shown in Figure 8.

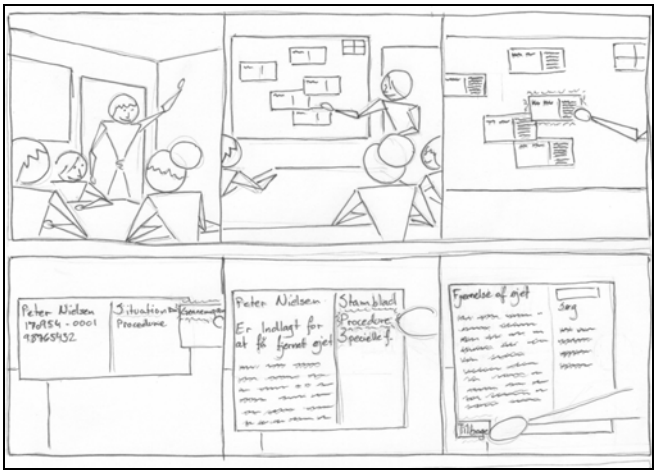

Figure 8 Scenario of indented system use

A total of three different hand drawn scenarios were created. An additional two written scenarios were constructed intended for the nurses to act out using a paper prototype of the system. The scenarios were inspired by our observations at the morning conference meetings hereby corresponding to actual tasks of the nurses.

6.2 Paper prototype

To show how actual interaction with the system would take place as well as letting the nurses act out scenarios, we created a paper prototype of our system.

To simulate the large touch sensitive screen we used a 60x40 cm blank canvas. Interface elements were printed on transparent paper, and cut out to be placed with thumb tacks on the canvas. That way system dialogue could be simulated by moving and/or replacing elements according to user interaction.

Interaction with the system and changes to the elements was simulated by exchanging one transparent with another displaying the new screen.

The entire prototype was printed in blank and white and therefore the colour encoding could not be presented. But was described by the authors and an example was discussed in relation to their record sheet.

6.3 Evaluation setting

The focus group interview was conducted in a meeting room at the hospital. All three researchers were present along with two nurses from the ward, which constituted the focus group. An audio recording of the meeting was made.

As an introductory presentation one researcher explained the general purpose of our project as well as a brief summary of the work performed since our last visit. Afterwards our intermediate design proposal was presented by showing the hand drawn scenarios along with a verbal explanation hereof.

Figure 9 - Nurse acting out a scenario

After a brief initial tutorial on how to use the paper prototype we asked the nurses to perform two scenarios by using the system. Figure 9 shows a nurse performing a selection task with the prototype. The interface was updated according to her action by one of the researchers.

For the duration of the test session which lasted an hour and a half there was a great deal of discussion regarding the system, interface ideas and the general concept. The nurses were exceptionally willing to discussing the system in the current abstract form and many topics of interest were identified and discussed by the nurses themselves.

6.4 Findings

In this section we present our findings from the focus group interview. We begin by arguing findings in relation to our key issues described in section 4.4 Afterwards we present a number of usability problems identified through the scenario acting, and finally we present a number of feature suggestions expressed by the nurses during the interview.

Figure 10 Discussion of an interface element

6.4.1 *Findings related to key issues*

By discussing the issue regarding redundancy in coordination with the nurses and presenting how our system could rectify this redundancy we noticed both appreciation and reluctance. They appreciated the fact that task responsibility and patient/nurse relations were stored in a common accessible way. One nurse was not thrilled about the concept of not having a piece of paper were she could make her own notes as this was important to her individual working routine. We presented the idea of printing a copy of the sheet, or accessing the information through a mobile interface such as the PDA presented in Section 6, which was seen as a useful solution. Furthermore we discussed that a common notation would have to be developed to alleviate the current lack of a homogenous notation practice. It turns out that the nurses record very similar information, but in a different manner. As an example one nurse uses a small dot to denote patients that could be discharged if needed. This was done by a yellow marker by the other nurse. The purpose was similar; if the ward is overbooked it is fast and easy to find dischargeable patients

A discussion regarding the key issue concerning lack of access to information for all participants revealed that the nurse in charge of the morning briefing is allowed to exclude certain information according to her own judgment of relevance. It was also mentioned that sometimes other nurses tries to peek in the journal she is reading from. They see a clear advantage of our design proposal were the nurse in charge can still be selective in what she reads aloud but everyone is provided with a complete view of the information

Even though it could not be displayed the nurses appreciated our description of colour encoding and the idea of supporting this in the system. Furthermore a nurse pointed out that she would like to be able to mark something as important within the system changing the encoding of that particular selection. This would require personal views to be implemented in the system, as what a single nurse marks as being important in her opinion should not be reflected as such for everyone else. An idea would be to support this feature through the use of the PDA interface.

6.4.2 *Usability problems*

A number of usability problems presented themselves during the process where nurses acted out the scenarios. A nurse mentioned that the naming of the journal button, see Figure 3 was not specific enough as both nurse journals and doctor journals exist.

Both nurses expected the button named “Medicinsk historie”, see figure 3, to present a history of test results, while we designed it to contain information about which medicine the patient had received. After discussing the nurses agreed that this information should just be a part of the “patient information”.

6.4.3 *Feature suggestions*

During the interview both nurses, realizing the potential of such a system, came up with proposals for system features, besides the one already mentioned regarding colour encoding.

The nurses told that during meetings it was often confusing to decide the status of various tests and it sometimes took several phone calls to decide whether a certain test was completed or even ordered. They expressed the need of an overview grouping various tests by kind and status as this would save a lot of the trouble which they experience now.

Overall the nurses seemed satisfied and eager about our system proposal and the initial response to the system was primarily positive, but some areas of improvement were identified. We were able to identify a number of new design specifications which could serve as a foundation of a next iteration of the design process.

- Printing the work sheet
- Common notation
- Personal views
- Test result page

In the next section we will present a design solution to satisfy the specification regarding the test result page, as this issue was stressed as a much wanted feature by the nurses.

7. IDEAS FOR REDESIGN

The redesign will attempt to remedy the shortcomings and will take into account the feedback from the nurses. We will only present one of the screens which have been redesigned to display the changes to the system as this page was an idea we had not observed during our empirical study, but it emerged during the interview. The nurses explained that when they need to order a test they have to make a phone call to another section of the hospital to order one. These results would then be placed in the patient record after completion, but it is not always that the results are delivered when they are completed and then they have to call again to get the results. These situations often involve making several different phone calls in order to get the test and delivery of the results coordinated.

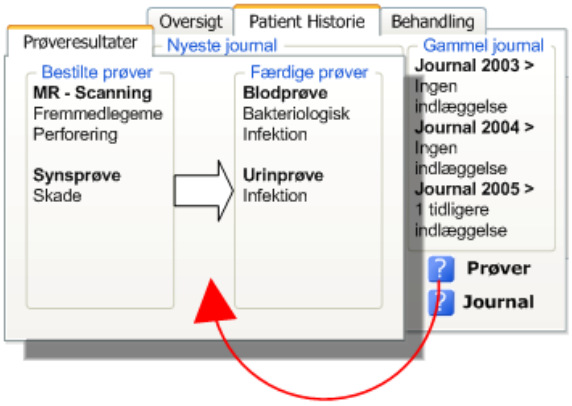

Figure 11: New Test results page

This was a coordination mechanism which we had not identified previously and which could be supported by the system. The requirement for a test initiates some coordination work between a nurse and other members of the hospital staff. The coordination is articulated through phone calls to other sections of the hospital. This is objectified in the patient record, were the test order is recorded and through the result page which is sent in return. Therefore we designed a new screen to support this while redesigning the buttons which were misunderstood.

Figure 11: New Test results page presents the redesign of the Medical history page which has been renamed to test results (“Prøver”) and now displays the medical tests which the patient has undergone. The nurses are able to access any of the finished tests and easily receive the results of the test. Furthermore the type of test and its current status is grouped according to the suggestions of the nurses. The medical history page has been

moved into the patient journal according to our finding during the evaluation.

8. LESSONS LEARNED

During this research project we have identified coordination mechanism to model the cooperative efforts of nurses during their meetings. We have found that this terminology provides a useful tool for formalizing the collaborative actions of the nurses and served as a feasible input to our design guidelines.

Our work has shown that a large screen for supporting collaboration is a welcomed idea in our specific case. Our focus group interview revealed that the users agreed with the concept of collaborating on large screens and they realised some potential advantages of the system. Even though we can not generalise on behalf of these results we can see them as a proof of concept for our design in this particular setting.

9. CONCLUSION

This paper presents a conceptual design of a large screen system supporting collaboration during staff meetings at a hospital ward. The design supports coordination mechanisms identified through observations of these meetings. The design was evaluated through a focus group interview with two nurses. They confirmed the key findings we have identified and were they were enthusiastic about the design which we presented. During the interview several new design specifications emerged and some misunderstandings were corrected, which created the foundation for a redesign of the system.

A limitation of this paper is that the empirical data we have collected is based only on two observations at the hospital ward and it might be necessary to perform additional observation in order to capture every aspect of what is being discussed during the morning meetings. But through our evaluation we learned only of one additional aspect of their work which was not directly linked to the collaboration during the meeting. Besides this there are three different groups of nurses were both our observations are based on a single group, it is possible that there are other practices in the two other groups which we have not captured. But these three groups of nurses are quite homogeneous and since we did not discover additional tasks during the evaluation we are confident that the material we have collected is representative for the morning meetings which are conducted at the ward.

An obvious topic for future work is an actual implementation of a complete version of the system. Currently a complete test at the ward is not a feasible option as the underlying EPR system is not ready for deployment. The focus group interview also revealed that the “work sheet” is an essential coordination mechanism in addition to serving as a repository of personalized knowledge. As stated by one of the nurses: “When we are overbooked I use the list to prioritize who can be discharged early”. This is a highly customized individual coordination mechanism which merits further research. A possible solution could be a customizable application for the PDA side of the system to support this. Another topic of further research is the ethical considerations prevalent in the healthcare sector. Danish law is very strict with regard to unauthorized access to medical files and history, and as such a study of the legal ramifications of employing a large scale electronic patient record system needs to be explored.

10. REFERENCES

[1] Bier, E. A., Freeman, S.: MMM: A User Interface Architecture for Shared Editors on a Single Screen. ACM 1991

[2] Bisgaard J.J., Heise, M., Steffensen, C: A literature survey of Single Display Groupware interaction for large screen collaboration 2005

[3] Bisgaard J.J., Heise, M., Steffensen, C., RegAid: A Context-Aware Healthcare System 2005

[4] Catrin, Björvell, Sygeplejerskens dokumentation – en praktisk håndbog, Studentlitteratur, Malmø 2001.

[5] Gerson, E. M., Star, S. L., Analysing Due Processes in the Workplace, ACM transactions on office information systems 1986

[6] Izadi, S., Brignull, H., Rodden, T., Rogers, Y., Underwood, M.: Dynamo: A public interactive surface supporting the cooperative sharing and exchange of media. ACM 2003

[7] Lopez-Gulliver, R., Tochigi, H., Sato, T.: SenseWeb: Collaborative Image Classification in a Multi-User Interaction Environment. MM04, ACM 2004

[8] Morris, M. R., Ryall, K., Shen, C., Forlines, C., Verner, F.: Beyond “Social Protocols”: Multi-User Coordination Policies for Co-located Groupware. CSCW’04, ACM 4

[9] Schmidt K. and Simone C., Coordination Mechanisms: Towards a Conceptual Foundation of CSCW Systems Design 1996

[10] Shoemaker, G. B. D., Inkpen, K. M.: Single Display Privacyware: Augmenting Public Displays with Private Information. SIGCHI, ACM 2001

[11] Stefik, M., Foster, G., Bobrow, D. G., Kahn, K., Lanning, S., Suchman, S.: Beyond the chalkboard: Computer support for collaboration and problem solving in meetings. Communications of the ACM 1987

[12] Stewart, J., Bederson, B. B., Druin, A.: Single Display Groupware: A Model for Co-present Collaboration. CHI’99, ACM 1999

[13] Sugimoto, M., Hosoi, K., Hashizume, H.: Caretta: A System for Supporting Face-to-Face Collaboration by Integrating Personal and Shared Spaces. CHI, ACM 2004