Enabling coordination within medical settings: case of a maternity ward

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Abstract

Purpose: This study evaluates the planning process issues in healthcare institutions that can be considered as a high risk environment. Most recent healthcare research has focused on methods mainly based on communication, rather than collaboration supports. *Material Methods:* We followed then a collaborative-based planning approach which constitutes an evolution of planning environment toward new shared workspaces supporting collaboration. Our work led us first, to analyse the related tasks in an Algerian maternity ward in order to highlight the vital collaborative medical tasks that need to be modelled. *Results:* the paper summaries basic design concepts of our collaborative planning system that is designed to make group interaction support flexible for care coordination and continuity. *Conclusion:* after development and test of our collaborative planning system, we noticed that our collaborative and planning system can increase awareness and hence decrease coordination breakdowns, reduce costs of information collecting and sharing. All these factors constitute a crucial aspect of an efficient management of a hospital.

Keywords: Healthcare tasks planning; Groupware; shared artefacts; collaborative planning; mobile applications

Introduction

Hospitals and healthcare institutions deal with the problem of the limited human and material resources. In order to achieve different tasks related to patients and to improve the use of hospital resources, an effective schedule of these resources becomes a necessity. This process is disturbed by several constraints and limitations, and the scheduling and the planning task is extremity hard due to several reasons, such as uncertainty of the demand of available resources, emergency and unexpected cases that disturb the existing plan… It should be noted that this problem is not limited only to underdeveloped countries, but it affects even developed nations.

To unveil the real reasons and to find a solution to this problem, we led a study based on interviews and observations in an Algerian maternity ward. We noticed that there are many reasons that are generally related to mismanagement of both human and material resources. The observational study has also revealed that almost all medical activities were achieved through a group work. This observation has showed also that many problems in patient management were linked to a lack or an absence of coordination between members of medical teams, which represents a very important aspect as it has been confirmed in several studies carried out about this problem [1]. Usually, the planning is done manually using some existing tools and sometimes using paper sheets. The problem with the existing scheduling and planning tools is that they do not take in consideration

preferences of different involved parts in the schedule, and papers are often not updated and even got lost because of the important work-load.

Generally hospitals and precisely maternity wards are considered as a high risk environment, because interruptions and exceptions constitute a part of daily routines. This kind of places is hard to manage, and they require coordination between several teams that are confronted to conflict situations during their work. Using new ICT (Information and Communication Technologies) will help to reduce coordination breakdowns through communication; cooperation and coordination support [14], and at the same time reduce coordination breakdowns that have a negative impact on the patient care chain. Following this method will offer collaborative supports to the medical staff that will help improving the patient care. Then, our work can be considered a part of the CSCW field (Computer Supported Cooperative Work). Therefore, we wish to provide an effective planning of the different medical tasks in addition to an effective awareness of events that happen in the maternity ward.

This paper describes the fundamental design methodology concepts of a new collaborative system for medical task planning CSMTP (Collaborative System for Medical Task Planning).

Material and Method

Related Work

According to the observations mentioned above, we considered the existing medical planning systems, and attempted to objectively analyse their characteristics. We want to provide an updated overview on medical tasks planning and scheduling that catches the recent developments in this sensitive area. We noticed that the majority of the observed studies focus only on one aspect, for example in [2] [3] researches are directed toward the planning of the already scheduled patients, and ignore operational deficiencies which are triggered by the arrival of non-already scheduled patients. Our observation revealed that only a limited number of studies take in consideration this category of patients. Numerous criteria are used to evaluate scheduling and planning procedures. We can distinguish between several main performance measures like waiting time, throughput (increasing the number of treated patients), patient deferrals, utilization, preferences...etc. In [4] authors formulate a two stage stochastic mixed integer program and propose a set of effective solutions that are easy for implementing to face the problem of long waiting lists. VanBerkel and Blake [5] use discrete-event simulation to observe how a change in throughput causes a decrease in waiting time. They disturb throughput by changing the capacity of beds in the wards and by changing the amount of available operating room time. Many studies treat and evaluate procedures based on an efficient utilization of hospital resources like operating rooms, which is a measure that includes both underutilization and overutilization [2][3]. Various solutions and evaluation techniques are applied to solve this problem, such as mathematical programming, simulation or analytical procedures like Gass and Harris in [6] and Winston and Goldberg in [7]. In [8]authors describe a discrete event simulation model to study how resource allocation policies at the department of orthopaedics affect the waiting time and utilization of emergency resources, taking in consideration both patient arrival uncertainty and surgery duration variability. We noticed that only few manuscripts refer to resource uncertainty [9], while this issue currently is very important [10].Thus, despite the progresses that have been achieved, most of these systems still favouring individual planning, and sometimes the scheduling task is left completely to an automated system based on mathematical models, rather than focusing the attention on the whole medical staff members while working together.

Our study of work in-situ led us to consider an Algerian maternity ward to well understand the standard way under which medical staff such achieve their tasks and identify the main used artefacts to coordinate the work. The maternity targeted is about 200 beds and comprises 4 operating rooms, 4 labour rooms, an analysis laboratory, an imagery centre, an emergency service, etc.

In this observational study we noticed that human and material resources can be shared between several groups. Making an effective plan to exploit these resources without a good coordination and awareness will lead to coordination breakdowns (Figure 1). Especially, with the

big amount of uncertainty inside the hospital. Here by uncertainty we mean, the unplanned patients' arrivals, which need sometimes an immediate use of some resources that can be used by other groups.
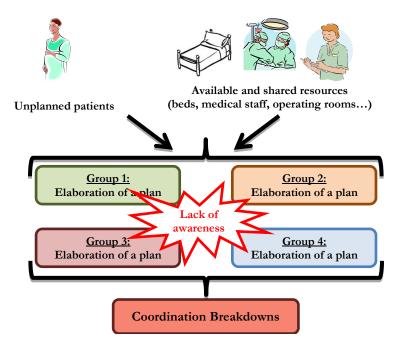

Figure 1. Process of planning

Our work attempts to design a shared social workspace in which experts can work together, discover shared interests and develop a feeling of a community. Thus, we have designed and implemented CSMTP, a first prototype supporting collaborative planning of medical activities. CSMTP design is intended with many pertinent objectives in mind such as taking in account healthcare professionals availability and mobility. The developed system allows users to achieve their tasks whether individually or collectively.

Mobile Applications

In the last few years, mobile technologies in particular emerged and become very important. Some countries reached an effective penetration of 100% such as Finland. In 2012, there are 35 million users of mobile phones in Algeria what represent 95% of the population [11].

Mobile phones support a variety of technical functions such as voice and short message services (SMS) which enable two-way communication in real time or near-real time. Capabilities of data-processing and storage of mobile phones increase each year. While many mobile phones remain only a way of communication, smart phones can do the same thing as a personal computer with adaptations to the mobile phone's small screen, keypad, or other user interface. All current phones can access wireless data networks whenever the phone has a signal, through GPRS, 3G, 4G connections or even through Wi-Fi (wireless fidelity), that enables data exchange via the Internet. Smartphones have made a renaissance in mobile computing. The applications running on Smartphones support vast new markets in entertainment, communication, commerce and medical field. As a result, Smartphone systems have become pervasive. Mobile phone applications are shifting from standalone designs to a collaborative model.

There are two kinds of mobile applications: native and web applications. Native applications are applications developed only for one platform: Android, Symbian, BlackBerry…etc. Web applications, are launched on a browser and can be used on any kind of platforms.

In this paper we opted to mobile collaborative system because of the greater ease with which users can reach and leave messages for one another, users have also permanent access to their mobile phones, which facilitates the use of reminders for medical appointments or information on lab results.

Our system must support notifications, instant messaging to allow medical staff to improve the schedule: schedule collaborative creation, schedule editing in real time…, all these functionalities can't be offered by a web mobile application, because it needs reloading the web page for each modification, that decrease the update rate, and make the collaborative process very slow and inefficient. A native mobile application has also its limits, but it allows the development of applications with rich interfaces, that meets with our needs. According to [12], the most popular mobile platforms are Google's Android OS (found on multiple devices), iOS (found only on the iPhone) and BlackBerry OS (found on Blackberries of various designs) [13].In this paper, we will take iOS platform as an example.

Results

Software Architecture

In this paper we developed a synchronous mobile groupware that enables real-time collaboration among collocated or geographically separated group members on an iOS platform.
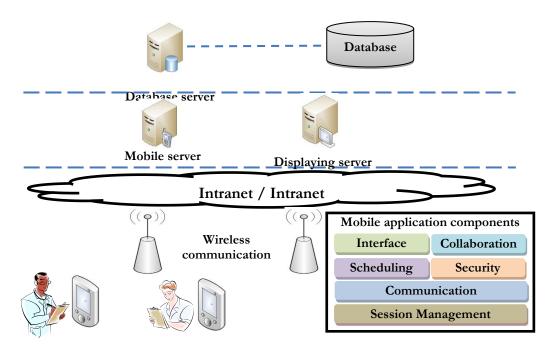

Figure 2. Software architecture

The first part of our software architecture presented in Figure 2 contains the system database which is mainly characterized by its capacity to provide concurrency control management, reliable data storage for long time, security capabilities and data storage. The developed system database contains all the necessary data for management and for the collaborative planning process as the list of available and occupied resources, list of tasks future tasks to accomplish. We used a relational centralised data base for many reasons: a reduced complexity during the development process and also because the data volume is small.

The second part contains all the software components. In the case of a real-time groupware, sharing data and events constitutes the most important aspect. Thus, enabling data sharing requires that any event or data generated by one user has to be immediately delivered and notified to all

other collaborators (in real- time). For better workspace awareness, fault tolerance, responsiveness, and replication of shared data objects are often used together with other operations on them like creation, updating, deletion and reading. There are many techniques to ensure awareness in mobile collaborative systems:

- **Database server:** The first layer contains as we mentioned it before, the database system.
- **Displaying server:** Our observational study, revealed us that placing artefacts in some specific places inside the maternity ward can improve the collaboration process, decrease coordination problems, increase awareness, reduce sharing and gathering information costs.

The Displaying Server is intended to display the schedule on Electronic Whiteboards (screens disposed on appropriate locations in the hospital). After every adjustment of the schedule, all the eWhiteBoards are automatically updated. Also to significantly reduce users' cognitive overload such as nurses, surgeons…, the eWhiteBoard(s) can be configured to restrict the display only for pertinent information needed by each group [14] and decrease the amount of data on screens.

- **Client machines:** consists of client devices, which are smartphones.
- **Interface Module:** this module plays the role of a medium between the user and the system.

The Interface module intercepts the local users' actions and sends them to the server via internet.

- **Scheduling:** This is the most important system component (Figure 3); it provides all the necessary tools for managing resources and tasks. The tasks list is displayed to the users in a table that showing all related tasks information (starting time, priority, location…). Once a task is created, it will immediately appear on the other participants (users) screens. So the authorized participants can modify it while the others get the latest information on their patients' state, and the cooperation process may naturally take place among the medical staff.

When a user joins a work session a set of information is displayed on his screen, the shown information concerns only that user. After a creation or an update of a task, an SMS is sent to the persons assigned to that task.

Figure 3. Snapshot of table of tasks

- **Collaboration:** to allow users to work simultaneously together, we designed several appropriate tools, such as the tasks shared table for example (Figure 3). Users share the same display which instantly shows any event that may occur in consequence of a user action. This technique provides users with real time awareness capabilities and enhances coordination among them. Furthermore, we take into account the ergonomic considerations while implicitly informing users about: "Who does what" through coloration use. Thus when a user starts editing a task, this latter is coloured by his specific colour (assigned once a user is registered). So users can easily identify the task author but also locate him.
- **Communication:** in order to coordinate their work, users must exchange their ideas. CSMTP supports both synchronous (Figure 4) and asynchronous communications. Through asynchronous communication, users can post comments, new messages, express their opinions, give valuable suggestions to their colleagues. We wish through asynchronous communication improve the efficiency of the shared schedule. However, when two users or more are working in the same time, they use the instant messaging tool to communicate synchronously.

Figure 4. Snapshot of the instant messaging tool

- **Session Manager:** This component is intended to manage users' work sessions. During the registration of a user, the administrator can specify his access rights on the schedule list (read/write). The Session Manager also manages users join/leave within the shared workspace, and any related event will be immediately notified the others such as latecomers...

Many other tools are available to increase awareness and help coordination, planning and patients management within the mobile collaborative system. Like the resources table that displays information about every resources (its availability, when it will be involved in future tasks to make planning future task easier).

The server extracts the required information from the database and uses an SMS gateway to send messages to the staff members. Messages can have single or multiple recipients. There are two message types: notifications to inform all the concerned persons involved in a given task, and reminders.

We developed another version destined for computers (and even for mobiles) based on HTML5 technology. The application is distributed on several HTML5 pages that are loaded on users' browsers.

Discussion

To develop our collaborative system, we followed an iterative and prototype-based design approach. During and after this development, a set of tests and evaluations have been carried out, which allowed us to fix and improve some of the proposed functionalities of the system. Experimentation of a system like CSMTP in an environment like hospitals is a very hard task that needs the intervention of several professionals from many fields. Another problem is that this kind of experimentations takes many months and sometimes many years. It is why we planned to make a first evaluation of our system with a group of students of medicine rather than test and evaluate it directly in a real context. Firstly, we collected information from the users about their opinions and their perceptions of the collaborative system. Secondly, we determined with more precision the appropriate adaptations we should apply to the supports provided in CSMTP, to meet with the users' needs. During this evaluation we took in consideration the following aspects:

- To evaluate whether the collaborative system favour social work, we worked with specialists in human sciences. Discussion with users after the use of the system gave us valuable information about group organization.

- To verify if the different functionalities meet with users' needs, we led a survey. Coupling this survey with some interviews helped us to identify functionalities that should be extended, modified and also if new ones have to be add. This survey helped us also to identify the different lacks concerning the user interface.

- We added a module working in background to monitor the different interactions during work sessions. Users gave also some suggestions of some new events that have to be notified.

At the beginning of the evaluation, it was easy for participants to make a plan. At the first it was a bit difficult to work with the collaborative scheduling table because of its shared nature that was a new functionality for them, but they do not take much time to be familiar with the environment. They could easily make a plan, create tasks and assign them to the different staff members. The interaction with the system was also very easy for them, which proves that our system is efficient at the interaction level.

In this first test, we noticed that participants configured their systems to receive all notifications. After a certain period; some of users change this configuration to be notified only about events that concern them and their group of work. Because the number of events was very important; and it was difficult to read all notifications. They also used both synchronous and asynchronous tools to exchange an important number of messages especially through their mobile phones. This proofs the utility of these tools within a group of participants to increase the interaction and facilitate their task. After the achievement of every task or action, participants post comments and information about it. Participants found this functionality very useful, and we noticed that communications between them using phone calls decreased significantly.

Although participants were not accustomed to use groupware, the flexibility of the proposed functionalities in CSMTP especially those allowing the improvement of coordination, helped them a lot to overcome this unfamiliarity which was a problem at the beginning of the test. The proposed collaborative system pushed participants to change their behaviour, but also gave them a sensation of collaboration and involvement. Another thing we noticed during this first evaluation, and as we mentioned it before that the number of phone calls between medical group members was significantly decreased. The huge number of calls that have as a goal keeping their information updated and also to coordinate their work is an important source of stress.

Through this work, we noticed that our collaborative and planning system can increase awareness and therefore decrease coordination breakdowns (by giving users the opportunity to schedule and organize future tasks together even if they are in the same place, what avoids them misunderstanding and confusion situations and every one reminds aware of every change), reduce costs and efforts of information collecting and sharing (notifications are sent automatically for the concerned staff after every modification of the schedule, so no need to call the others to ask every time if there is something new or no). All these parameters constitute a key factor of an efficient management of a hospital.

Conclusions

In this paper we proposed a mobile collaborative system for medical task planning, in which computers and mobile devices are used as the front end. The developed system aims to offer interactivity and mobility users who are not in a face to face situation to collaborate in a shared context. One of the main emphases of this work was to add the feature of collaboration and coordination to the mobile distributed medical system, allowing cooperative work among distant users.

Building a groupware system such CSMTP remains a very hard task to achieve, because it requires first to understand the tacit and invisible aspects of group work practices. It is necessary also to notice that translation into explicit requirements is not straightforward and requires

extensive investigation in real world situated group work. Indeed participants often express various requirements while working together on a common task.

Medical activities' planning sharing has been discussed. The efficiency of this planning is increased through the incorporation of an awareness mechanism that allows informing participants of their mutual actions. A simplified mobile application application is used to display the schedule to participants, taking in consideration reduction of users' cognitive loads, that enables them to know what is happening and get information about their patients' state as well as their next tasks that should be accomplished.

To objectively measure the efficiency of CSMTP, we have implemented and tested a first prototype. The different evaluations have allowed the improvement of the proposed system. The opinion of the participants is that the system is useful and very necessary.

Conflict of Interest

The authors declare that they have no conflict of interest.

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