Interruption Management for Hospital Communications Systems

A user requirements study

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***Abstract*—Working in a hospital environment requires highly mobile personnel. To facilitate the increasing need for exchange of patient data between healthcare professionals, mobile communication devices are used. Mobile communication devices also increase the occurrence of inappropriate interruptions during clinical task performance. These interruptions have been related to decreased quality of clinical care. User requirements were elicited using a scenario-based approach. The results present insights into user requirements for an interruption management system for hospitals. Hospital workflow protocols were identified as a major source of interruptions. Suggestions by participants for managing these interruptions related to improving workflow using IT instead of merely preventing interruptions. We have shown that even though the hospital is an exceptionally demanding environment, the user requirements for interruption management concur with earlier findings in the broader fields of context aware interruption management and computer supported cooperative work.**

Keywords-Hospital communications systems; interruption management; workflow support; user requirements

I. Introduction

Medical personnel's working environment requires them to frequently move around during their work and at the same time be able to communicate with colleagues when needed [1–3]. Mobile communications devices, which are used to make this possible, have introduced a new problem; increased interruptions during their work related tasks. Such interruptions increase the likelihood of several negative consequences [4–8].

This situation calls for help to balance between increased availability and increased interruptions. This has been discussed by Solvoll and Scholl [9], who analysed the need and user preference for a better communication system. The CallMeSmart project at the Norwegian Centre for Integrated Care and Telemedicine, University Hospital of North Norway, has presented one approach to solve this problem. In CallMeSmart decision making is supported by a rule-based system. The rules and resulting actions must reflect the wishes of the medical personnel [10].

The purpose of this study is to formally verify and possibly identify additional requirements for a system aiming to achieve our overall goal – to find a way to balance between the increased availability and increased interruptions.

In this paper a user-oriented approach is used to verify and expand identified user requirements for an interruption management system for mobile communications in hospitals. The paper presents the results from interviews and discussions with doctors and nurses concerning interrupts in their daily work situation. This study was previously presented as a poster [11].

II. Materials & Methods

A. *Eliciting User Requirements*

Several different techniques can be used to elicit the requirements of a system from the stakeholders. In the early stages of a project, techniques such as interviews (Fig. 1) and user observation can be used to clarify the problem. When some knowledge about the stakeholders and their requirements has been acquired, workshops and brainstorming can be used to define requirements for the system. Carroll [12] argues for the use of scenarios in the design of human-computer interaction (HCI). Lu and Bao [13] propose that context aware service design should be scenario driven process. Benyon and Macaulay [14] lay down a framework for their use in human-computer interaction.

The user-system interaction scenarios can be written based on the previous steps. Creating the scenarios according to a specified framework, as described by Benyon and Macaulay [14], helps to shape it into a multidisciplinary design tool. This is useful since the next step is to formalize the interactions in use cases. A prototype can be used to play out the elicited concrete scenarios and if necessary to refine the service.

The framework laid down by Benyon and Macaulay [14] consist of two main approaches to uncover the design dimensions and their aspects. First the user-centred perspective is characterized by Person, Activity, Context, and Technology (PACT). After the PACT aspects have been uncovered, the designer-centred aspects, Function, Interactions, Content, and Structure (FICS) can be discussed.

 ISBN: 978-1-61208-327-8

Introduction
Background figures, information, and study aim.
Introducing the interview structure.

Checking user story
Are there any critical situations missing?
Do you think the situations are realistic?

Interruption management
Introducing the CallMeSmart prototype:
- Its context aware features
-The envisioned interruption management techniques

Discussion
Discussing the conceptual scenario and PACT aspects.
-Do you think the concept is useful?

(P) Who do you think will benefit from this system and who will use it?
(A) How and with what purpose would you or others use the system?
(C) When and where?
(T) What kind of devices would benefit?

What will adoption success depend on?

Figure 1: The interview protocol based on the PACT framework.

Hevner et al. [15] describe a framework for information systems research. This framework divides business needs in three categories, People, Organizations, and Technology. The PACT framework seems to mirror these elements. Continuing the framework laid out by Benyon and Macaulay [14] also complies with the guidelines on research conduct, as stated by Hevner et al. [15].

Sutcliffe [16] has also described the use of scenarios throughout the design process. In the first phases of system design he describes his scenarios as 'visioning scenarios', 'scenarios of use', and 'context and use scenarios'. These three types of scenarios again mirror Benyon and Macaulay's [14] framework for scenarios throughout the design process.

Go and Carroll [17] describe the use of scenarios in HCI and requirements engineering. Their article also describes the shift of scenario usage from a single user with a single device to computer supported cooperative work. In a project these different levels of scenarios can also be used, as Benyon and Macaulay [14] also argues for a broad use of different types of scenarios throughout the de-sign process.

Two projects in context-aware systems by Bardram [18]. and Favela et al. [19], similar to CallMeSmart, have also applied scenario design in some form.

Bardram [18] wrote about scenario-based design in computer supported cooperative work. He agrees with Benyon and Macaulay [14] on the dynamic nature of scenarios throughout the process. This work describes various types of records, oriented towards different aspects. The 'organizational' and 'personal' oriented records resemble the PACT aspects. The 'object' oriented record on the other hand, resembles the FICS aspects.

Favela et al. [19] have used a less formalized scenario structure to illustrate typical environment in which their solution has to function and how it does so.

Scenario design and the framework for the actual scenario will be performed according to the framework presented by Benyon and Macaulay [14]. This approach includes the PACT and FICS aspects. The Structure aspect of FICS is however replaced with a Service aspect as presented in other studies [20,21].

Scenarios in HCI design have been used for different and sometimes contrasting goals. Sometimes scenarios are meant to leave room for discussion and interpretation, while on the other hand, scenarios and their adaptations are used to deal with any present ambiguities [14].

In this research the conceptual scenario is supposed to leave room for discussion. The scenario describes a generalized day of a physician, performing several recognizable tasks, such as handover meetings, consultations, surgery, and patient rounds. In this conceptual scenario, the CallMeSmart system is used for managing mobile communications. The scenario was presented and discussed together with a parallel user story, mirroring the same tasks, but without the interruption management system. The complete scenario document is not included here due to space limitations.

Concrete scenarios should eventually deal with any remaining ambiguities, so the system requirements can be clearly defined. After the developers have been involved in formulating the concrete scenarios, the results should be evaluated by potential users before proceeding to the next step. The resulting requirements can then be used to guide software engineers who have not been part of the process so far and have less knowledge about the subject. In this way, a formal user oriented approach is applied, similar to the development of the first prototype described by Botsis et al. [22].

B. Data Analysis

The scenario discussions were recorded and transcribed. The participants' expectations of, and opinions on, interruption management systems were compared to the literature based on the PACT framework, on which the scenarios are based. The focus was on the similarities between the interview results and various parameters and abstractions that are used in context-aware and interruption management literature [23-27].

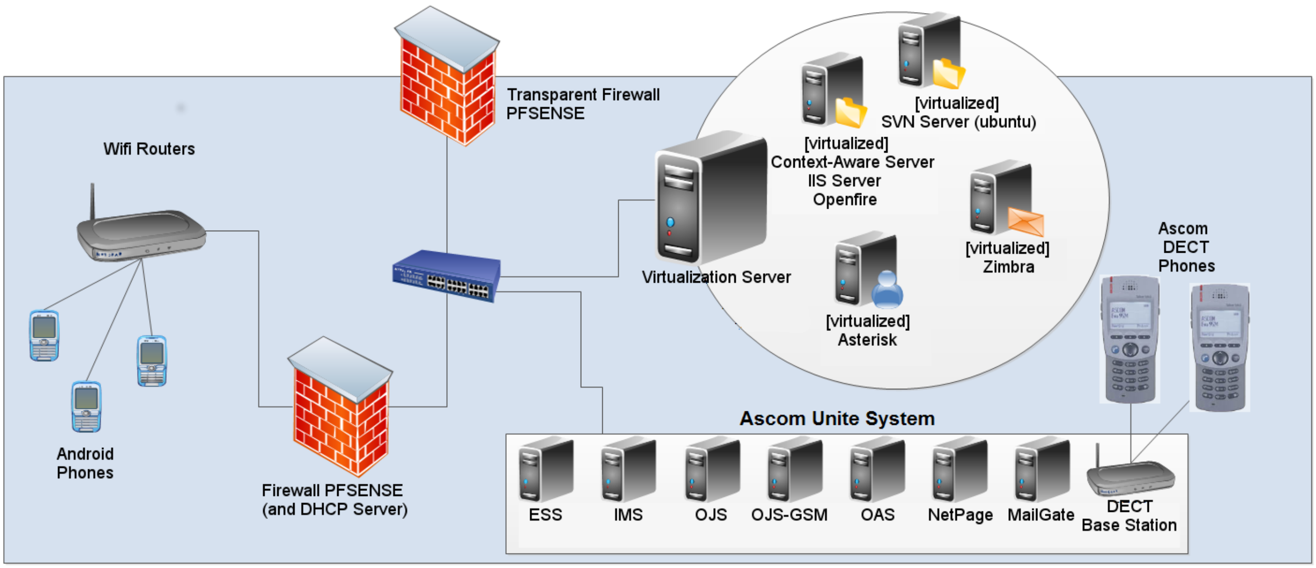

Figure 2: CallMeSmart prototype network structure

C. *The CallMeSmart Prototype*

A working prototype of the CallMeSmart system has been developed. The network on which the CallMeSmart prototype operates is shown in Figure 2. Interruption management can be provided for both android-based smartphones and tablets, as well as for Ascom DECT-phones. The interruption management service itself runs on a server, which also serves as a private branch exchange (PBX). A PBX facilitates in-house phone communications for organizations and businesses, including hospitals.

A context aware application handles data and sends relevant information to a call handling script to provide the correct services at the right moment. For more information on the softphone and android mobile devices, see Solvoll et al. [10]. There are several theoretical frameworks in which CallMeSmart can be placed. Here we will introduce three of them.

De Guzman's classifications of 'receiver oriented', 'negotiated', or 'caller oriented', as presented by De Guzman et al. [23], fit the CallMeSmart system clearly in the 'caller oriented' category. Of these three categories, 'caller oriented' is the only one that doesn't require any attention from the user. In the hospital environment, reducing interruptions would only be achieved by such a 'caller oriented' system.

The CallMeSmart system implements 'burden-shifting', 'time-shifting', and 'activity-based sharing' as used by Lindqvist and Hong [24]. The burden is shifted, because the first step, if a user is busy, is to notify the caller of the user's inferred situation. The options presented to the caller, the interrupter, allow for 'time-shifting'. The 'time-shifting' can be achieved by suggesting using other, conventional, technologies, such as messaging or voicemail.

The design dimension axes of availability sharing, as defined by Hincapie-Ramos et al. [25], can be used to classify CallMeSmart. The system abstracts the sensor data to a 'discrete' 'availability' mode. 'Implicit interaction' is used to present the data whenever necessary. The presentation of availability data is 'asymmetric', since you do not need to share your status to be able to identify the status of the person you're trying to call. When two persons are in each other's contact list, their status sharing could be called 'symmetric'. Connected to the 'symmetry' dimension is the 'traceability'. Here Hincapie-Ramos et al. [25] defined parameters, which do not describe the possibilities for the dimensions they identify as accurately as the parameters in other dimensions. The system can be either 'blind' or 'traceable', according to the framework. This represents the systems options to let users know not only how and when others see them, but also who these others are. In this aspect, CallMeSmart is however two thirds blind. The status callers get to see is the same as the status shown on the user's phone. Information on who has viewed a user's status and when they have done this, is however not being registered. CallMeSmart's obtrusiveness along the axes is 'selectively focal'. On the 'temporal gradient' it focuses on users' 'current availability'. With the identified design dimensions, CallMeSmart adheres quite close to the optimal dimensions identified by the authors. The main difference is the 'blindness' in the information 'asymmetry'.

III. RESULTS

The results presented here are representative quotes from interviews and discussions, which led to interesting new insights. This section is organized following the PACT framework.

Quotes of the three doctors are identified by Dr. A, B, and C. The nurses' quotes are identified with nurse A, nurse B, and nurse C.

Discussing the aspects of the PACT framework led to some interesting insights into the wishes of the intended target environment and users. While discussing aspects of

 ISBN: 978-1-61208-327-8

the framework, some obtained results were more relevant to other aspects and are presented there.

A. Persons

As nurse A stated:

"The doctors are definitely the ones who are the most disturbed."

Dr. A stated however, that he expected:

"The most advantage is for the caller."

Dr. B made an interesting remark about the sources of interruptions.

"We have incoming calls all the time, from GPs [general practitioners], wanting to ask questions."

Previously Dr. A had already mentioned a possible solution for this, now verified, problem:

"He[a general practitioner] should have an option, if it's urgent he gets through, if not he can wait. It could be very useful for the GP. Including GP's directly, system can help more than switchboard currently does."

Dr. C generalized this even further saying that:

"So many interruptions are from outside the hospital. Personal, from family, or even media trying to call. There should be a barrier to calls from the outside [of the hospital]."

B. Activities

The CallMeSmart prototype has the option to hang up after hearing the callee is busy, without this information being shared with the callee. In a reaction to this feature, Dr. A stated the following:

"I would strongly suggest making it an option to be able to see everyone who has tried to reach you, even if they decided not to leave a message. I guess some people would like to know that."

Nurse A suggested that the possibility for everybody to send text messages will lead to more asynchronous communication.

"[about messages]It's the same as when we started to use e-mail [on desktop computers]. You don't need to synchronize communication."

Dr. C made the same point and voiced the need for a way to handle any backlogs that might occur.

"They will need to prioritize this backlog of communication requests. Maybe color-coded. They should be able to give these prioritizations themselves."

Which was directly in line with Dr.A's request for:

"Some asynchronous feature to allow me to start working, which should also show priorities to the pending messages and call back requests."

To which nurse C added an interesting idea, which however wasn't mentioned by anyone else. The idea is that users should be notified when calls initially directed at the user are successfully handled by a colleague.

"An overview of all calls and messages that don't need further follow-up would be useful."

Two typical answers when talking about the activities aspect came from Dr. B and nurse A respectively:

"If you had a function that could let you say "I'm busy" or "ask me via sms" that would be nice. A function where you set up the busy button as similar to the silent mode, or as a response to a call is feasible to think about."

"Standard messages are a good thing. If I can't reach someone who will be available in a minute I won't have to use my time to find someone else to answer my question.(...) Maybe an option to let the callee know when someone is trying to call and let the caller know when he will be available, though this is an interruption."

An interesting remark from nurse B reflected a topic that came up several times with several participants:

"If you know where a person is, you know he's busy and why and thus call a different person."

C. Context

Two quotes from Dr. A and B respectively, made it clear that they do not want to be disturbed in the operating room (OR).

"The operation setting is the most important one. That's a situation where people really don't want to be disturbed."

"They're always busy in two places, the trauma room and the OR. If you're there, you're busy, that's the name of the game."

Dr. B also stated that the contexts, from which many interruptions originate, are standard situations, dictated by protocols, for example:

"Most nurses are experienced, but need to have the doctors' permission. […] It's like, can I take aspirin or paracetamol for pain, of course, but they have to ask for permission. It's the doctor who's responsible for the patient. That's a very typical situation. It would be nice to have a way to arrange that".

D. Technology

To be able to integrate any solution in the hospital environment, Dr. A advised the following:

"I would be careful to exclude options, someone might prefer the pagers."

Dr. C clearly stated an issue that came up more often.

"It would be nice if you could use the system on a device like an iPad and have information, like the EPJ, integrated."

E. System Adoption

A subject that came up with all the participants was clearly stated by nurse A:

"It is more the culture to want the answer now. You need to teach the people that they don't need the answer right now."

Dr. C formulated an issue that was mentioned by all doctors participating in this research:

"If the doctors can't trust the system to be consequent and reliable, they will go back to their old system."

A concerned voiced by several participants was explained by Dr. C in the following way:

"Doctors will be the main users of the system. They might however try to use the system to put up a cocoon around themselves, using it as a barrier and not as a tool. Some doctors currently switch of their phones, or never turn them on. They might use the system in a similar way, always keeping their phone on busy."

IV. DISCUSSION

Widya et al. [20] pose that scenarios should be very domain specific for participants to recognize the situations. In the CallMeSmart project, more general scenarios have been used. This was intentionally done for several reasons. The first of which is that the CallMeSmart system is meant for many different sub-domains inside the hospital. It also enabled discussions of the scenarios with healthcare staff from the various disciplines, which were available for this research. Even though it was not very domain specific, several interviewees spontaneously noted that they could relate to it.

There was, however, one physician who felt unable to participate in this research. This was because the physician did not recognize personal work situations in the scenario.

When the system is being customized for a hospital and its departments, very domain specific, detailed, accurate scenarios can be used. The local policies, user habits, and preferences can then be taken into account. The current scenarios are also quite fragmented. This fragmentation is the result of the systems' wide range of functions and options for the varying situations. Since many functions are replacing functionalities of current communication systems, they could be given less attention in future user requirement research.

Only a limited number of medical staff participated in this study. They were from widely varying backgrounds, which had several consequences. The results represent requirements of a wide variety of hospital workers, i.e., nurses, an anaesthesiologist, a surgeon, and a department head. The participants did not, however, discuss the results with their colleagues. It could be that the current results include personal opinions or suffer from oversight.

A. Persons

One might expect doctors, as senior responsible staff, to gain the most benefit from interruption management. During interviews however, both doctors and nurses brought up the benefits they expected the interrupters would gain. Interruptions are generated by a need for information to accomplish a task. Proper interruption management would have to deal with these information requests, thus facilitating the work of the interrupters.

It was interesting to note that medical personnel seemed very annoyed by calls from outside the hospital. It could mean that either the volume of interruptions is indeed high, or that these interruptions more often occur at inappropriate moments, due to even less knowledge about the availability of the callee for the callers. Either way, this source of interruptions should be considered in designing an interruption management system.

B. Activities

One of the doctors made an interesting remark on the symmetry of information sharing. When the CallMeSmart system intervenes, a caller can infer information about the person in question, thus enabling the need for traceability measures, as discussed by Hincapié-Ramos et al. [25].

The expected increase of asynchronous communication has been shown to increase efficiency in hospital work [7]. Managing these communications could further increase the efficiency.

It is interesting to note that users came up with ideas for handling interruptions in ‘receiver oriented’, ‘negotiated’, and ‘caller oriented’ approaches, as described by De Guzman et al. [23]. They also expressed a strong preference for interruption management not only ‘during switch phase’, but also ‘after switch’, as described by McFarlane and Latorella [26]. The notion to classify communications by priority will probably suffer from the same mismatches in perceived urgency between users as described by Wu et al. [7].

‘Awareness’ or ‘presence’ cues were suggested as a way to reduce interruptions. These cues can be visualized by icons and represent contextual information, such as location. The CallMeSmart project does not have this feature, as it requires extra time investment from the users, every time they want to make a call. This was assumed to be unfavorable for efficient system adoption and the good results achieved by Oulasvirta and Petit [27] were not expected to be reproducible in a hospital environment.

C. Context

All participants emphasized the significance of interruptions on the OR. They emphasized that the first problem that should be solved are interruptions on the OR and ER. Even if a system would only solve interruptions on these locations they would like to try it.

D. Technology

Including options to integrate the different devices could lead to higher adoption rates, because it doesn’t require users to switch to a new device. It would however also give users the option to handle a larger variety of interruptions via mobile communication devices. The use of tablet devices to handle interruptions could lead to more mobile workflow support of users, while their information requests to each other can be managed by CallMeSmart.

E. System Adoption

Three main issues for adoption were identified. Firstly, hospital personnel will have to get used to asynchronous communication. Secondly, the system should be reliable, consistent, and transparent for users to understand its functionality. Thirdly, users will have to be loyal to the system, using it in the way it is intended. Trying to use the system as an extra barrier all the time will not lead to successful implementation.

F. Insights gained

The potential users suggested new ways of managing interruptions, but also suggested integration of the communication system with other hospital IT systems.

Though the interviews yielded a lot of ideas on interruption management, many of the mentioned causes for interruptions originated from workflow protocols. The participants would often offer solutions which would change the workflow. This is interesting because of the comments

 ISBN: 978-1-61208-327-8

on system adoption, where participants stated it should not require change to the current processes.

Although the study included only a limited number of participants and the results might therefore not be generalizable, it is suggestive that their opinions do highly correlate to the literature of the wider field of context-aware interruption management.

The study aims of Bardram and Favela, to support computer workflow instead of managing interruptions directly, is interesting [18,19]. According to our findings, supporting workflow could further reduce the need for interruptions.

V. CONCLUSION AND FUTURE WORK

The requirements, elicited using scenarios, match with the broader literature of interruption management and previously identified requirements. Wishes of medical personnel adhere to previous literature in the broader fields of context awareness and interruption management. Computer supported cooperative work is closely related to interruption management due to its potential to reduce the need for interruptions.

The CallMeSmart system has been further developed according to the feedback from the users and is now ready to be tested in clinical settings. This pilot will start during January 2014, and CallMeSmart will first be installed and tested at the Oncology department at University Hospital of North Norway. The results from this pilot will be published during and after the pilot, late 2014 and 2015.

ACKNOWLEDGEMENT

This work was supported by Norwegian Research Council Grant No. 174934. We would like to thank the doctors, nurses, and developers who participated in the process.

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 ISBN: 978-1-61208-327-8