Message-Based Patient Guidance in Day-Hospital

Patrick Lamber*, Bernd Ludwig*, Francesco Ricci*, Floriano Zini*, and Manfred Mitterer†
*Free University of Bozen-Bolzano, Faculty of Computer Science
piazza Domenicani 3, 39100 Bolzano, Italy
Email: patrick.lamber@lamber.info, ludwig@cs.fau.de, francesco.ricci@unibz.it, floriano.zini@unibz.it
†Hospital Franz Tappeiner
via Rossini 5, 39012 Meran (BZ), Italy
Email: manfred.mitterer@asbmeran-o.it

***Abstract*—Day hospital workflows are highly dynamic. It is, therefore, important to provide patients with timely information about their next activity, where it takes place, and when it starts. In this paper we present *MobiDay*, a novel mobile service integrated in the hospital information system that supports patients and clinicians in a day hospital scenario. We describe the *MobiDay* message–posting algorithm that uses context–aware rules provided by clinicians to decide the time and content of the guidance messages sent to the patient's device. *MobiDay* was tested with real patients during a 4-months-long experiment held in the hospital of Meran in South Tyrol, Italy. Here we report on the system evaluation results. Moreover, we discuss the pros and cons of *MobiDay* design choices and propose some general guidelines for the development of effective message–based mobile guidance services for patients.**

I. Introduction

Mobile and pervasive devices are becoming primary instruments for information access, data acquisition, and ubiquitous service provision. This is true also in healthcare systems [1], [2], although progress in this domain has not been as marked as in other fields [3]. The regular use of pervasive and mobile healthcare information systems is still a long way off [2]. As a consequence, an important precursor to the deployment of such systems is an understanding of the impact they have on the work organization of clinicians and their acceptance by patients [4].

In this paper we describe *MobiDay*, a mobile system that we have designed, implemented, and deployed in a clinical setting for supporting patients and clinicians in a day hospital scenario [5]. *MobiDay* provides patients with context dependent messages that offer instructions for executing their tasks as part of the day hospital workflows. Using *MobiDay*, the patients can receive, fill out, and submit questionnaires on their quality of life to provide clinicians with an accurate picture of their health status. Our research explores directions of pervasive and mobile computing in healthcare which, as previous work acknowledges, are rather different from those found in other more mainstream applications [2]. There are three aspects of *MobiDay*, which are important to mention: First of all, *MobiDay* is a fully integrated in the hospital information system and is integrated with two legacy systems: The first manages the patient health records and their day hospital workflows (*ONCONET*); the second manages quality of life questionnaires and their statistical analysis (*CHES*). Secondly, *MobiDay* focuses mainly on the patients and is aimed at bringing the benefits of mobile and pervasive technologies to them. The hospital staff, who were the main target in previous systems, receive an indirect advantage in terms of a reduced effort in assisting patient activities. Thirdly, *MobiDay* provides patients and clinicians with several functions integrated in a unique system. According to the classification proposed in [2], *MobiDay* is a *three-function system*: the filling of quality of life questionnaires is a *information and documentation* function, the guidance service in the hospital workflow can be classified as *support*, and the consequent optimization of the management of the hospital patient workflow as *process automation*. Examples of systems providing one or more of these functionalities are described in [6], [7], and [8]. Different from these systems, which are mainly targeted at improving the work of clinicians, *MobiDay* focuses on the patient, who is the direct user of *MobiDay* and obtains firsthand benefits.

The main focus and contribution of this paper is the design and analysis of the guidance service that pushes messages on patients' mobile devices to inform them about their next day hospital activity and where it takes place. We show how the proposed service can be implemented on top of an infrastructure that includes ad hoc technologies and legacy systems. We also show that the guidance service, which is based on decision rules elicited from the hospital clinicians, can be adopted in the hospital and outline the benefits and drawbacks for the users. Finally, we analyze the recorded behavior of the patients during the system usage and derive insights about the strengths and limitations of the general design choices behind the guidance service. The result of the analysis allows us to derive some general guidelines for developing a guidance service in the hospital.

II. Overview of MobiDay

A. The day hospital scenario

In the typical *MobiDay* usage scenario, the patient enters the hospital for a scheduled visit and treatment. She first approaches the registration desk where she receives a badge (active RFID tag) and a mobile phone where *MobiDay* is installed and running. Figure 1-a shows the main panel of the *MobiDay* client, where the patient can see incoming messages

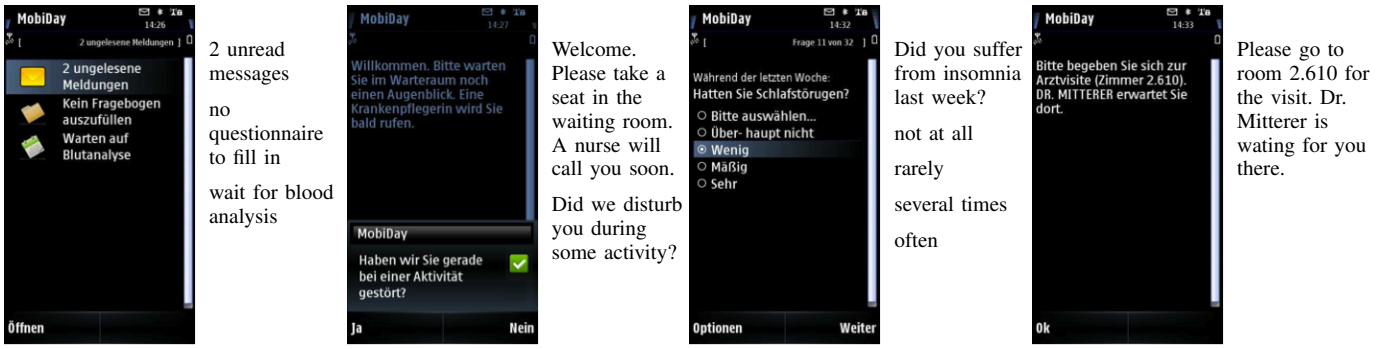

Fig. 1. *MobiDay* user interface: (a) main panel; (b) feedback acquisition; (c) questionnaire filling; (d) guidance message.

and questionnaires[1]. After this registration *MobiDay* system sends the user a welcome message, informing them to proceed to the waiting room (Figure 1-b).

When it is her turn for blood analysis, the patient receives a new message informing her that she has to move to the therapy room, where the blood sample is taken. After this step, she is sent back to the waiting room. At that point *MobiDay*, knowing that the patient is currently waiting and has time, retrieves a questionnaire about the quality of life from the *CHES* system (illustrated in Section II-B) and sends it to the patient. The patient can fill out the questionnaire (Figure 1-c) and send it back to *CHES*, so that the doctor can analyze this data prior to the medical visit. Next, when the medical examination is ready to start, the patient receives another guidance message (Figure 1-d) informing her that the doctor is ready to see her. Based on the outcome of the visit and on the answers to the questionnaire, the doctor decides the therapy for the patient who receives, when back in the waiting room, a new message informing her that she will be called for the therapy when her treatment is ready. When the therapy is completed, the patient receives a "good–by" message that also reminds her to return the mobile device to the secretary.

Some of the messages were chosen randomly by *MobiDay* for evaluation by the patient. In these cases, a question about the appropriateness of the message was popped-up and the patient could express her feedback (Figure 1-b).

B. Architecture

The high level architecture of *MobiDay* and the information flow between this system and the integrated legacy systems are illustrated in Figure 2.

The *MobiDay* server is a J2EE application that implements the business logic of the system. The *MobiDay* server is responsible for reading and storing the contextual state of the patient. The patient's contextual state aggregates data managed by the legacy system *ONCONET*, which deals with the patient workflow, and location data of the patient, produced by the *RFID localization system*. The user context provides

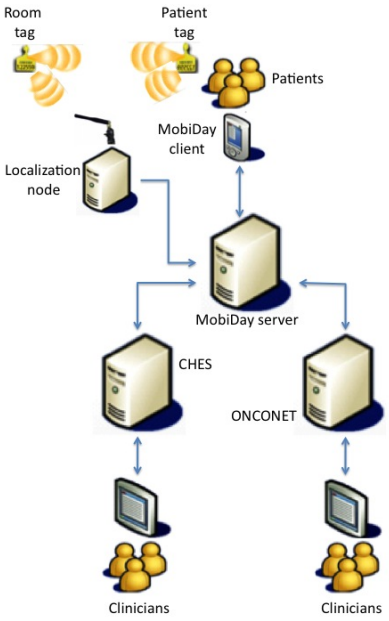

Fig. 2. Architecture of *MobiDay*.

the input to a message–posting algorithm (see Section III-B) that decides whether a guidance message or a questionnaire should be generated and sent to the patient's mobile device. If a questionnaire has to be sent, the *MobiDay* server interacts with the legacy system *CHES* for the elaboration of the correct quality of life questionnaires.

The *MobiDay* client is a *Java 2 Micro Edition (J2ME)* [9] application running on the patient mobile device. J2ME is a Java platform for building native mobile applications, and altough may compare poorly (look and feel) with respect to newer platforms (e.g., *Android* or *iPhone*) it is supported by a larger set of phones. The client/server communication exploits a protected WiFi network of the hospital[2]. The client periodically polls the server requesting pending messages and

[1]German has been adopted for the *MobiDay* user interface because it is the language spoken by the majority of patients in the hospital of Meran.

[2]The WiFi network is commonly used in our application scenario, and interferences with medical instruments was not raised as an issue by the hospital IT department.

questionnaires. If this is the case, the client retrieves them and notifies the patient of their arrival. When the patient receives, starts, or ends reading a message, these events are sent to the server, so that the current contextual situations of the patient can be recorded together with a log of the event. In order to build a more robust solution, the *MobiDay* client uses a J2ME record store to store locally the contextual data and sends them to the server when the communication can be established.

ONCONET is the primary hospital information system [10]. It stores patients' electronic health records and is used to schedule the periodic visits of the patients. During each visit, the nurses use *ONCONET* to manually advance the patient state in the workflow. The *MobiDay* server asks *ONCONET* for the patients workflow state, and consequently decides what type of message to post.

CHES (Computer-based Health Evaluation System) is an innovative application used to collect data about the psychological and physical status of patients [11]. *CHES* allows the clinicians to submit to their patients standardized questionnaires, as that on the "Quality of Life" [12] and to automatically elaborate their answers into consistent indicators on their health status. The *MobiDay* server, when it is the right time for filling a questionnaire, based on the patient context data and the posting algorithm, retrieves it from *CHES* and sends it the patient's mobile device. Questions are presented to the patient one-by-one, and she can stop and restart the fill out. Once the patient has completed the questionnaire, it is sent back to *CHES*, for the elaboration of the patient indicators on her psycho-physical conditions. The clinicians can then connect to *CHES* and examine this data.

The *RFID localization system* is composed by a number of RFID [13] *localization nodes* (two nodes were needed in our case to cover the area of the day hospital ward) and by RFID tags positioned in the rooms of the day hospital (*room tags*) and distributed to the patients (*patient tags*). Each *localization node* continuously collects *contacts* between *room tags* and *patient tags*. The number of contacts between a pair of tags in a time unit depends on the distance between them. Therefore, the room tag with the greatest number of contacts with a given patient tag identifies the room where that patient is currently located. The *MobiDay* server queries the *localization node* in order to acquire the last position of any patient.

All the components of the architecture are co-ordinated by the *MobiDay* server in order to provide to the patients and clinicians the system services. In the rest of the paper we will focus on the description and analysis of the *guidance* service for the patients visiting the day hospital.

III. Patient guidance service

The guidance service provided by *MobiDay* supports the patients in the execution of their hospital tasks. For example, by using the system they need not to find and ask somebody whether their turn has come, or they can move around in the hospital without the fear of missing any calls from the nurses. The guidance service is beneficial also for the clinicians, as it relieves them, especially the nurses, from the burden of calling and accompany the patients where their next activity take place. The automation of the patient guidance was requested by the clinician for better organizing the day hospital work, dealing with a larger number of patients, and providing a better service to each of them.

A. Design choices

The design and implementation of a guidance service for the day hospital required us to address the following issues.

- Even though the patient activities are ideally organized in well defined workflows, the hospital is actually a highly dynamic environment where the waiting times between activities and even their actual sequence are sometimes difficult to predict. Therefore, it is important to implement a reliable mechanism for providing the patients with timely and accurate information, on the basis of their current situation.
- Patients face serious diseases and, for this reason, they may be physically and/or psychologically weak, and focused almost exclusively on their disease. Therefore, the guidance service should be able to effectively capture their attention when a message is notified.
- The average age of patients visiting a day hospital is significantly greater than the age of habitual consumers of mobile technology. This introduces a problematic element that needs to be addressed by adopting easy-to-use and to understand applications.

In *MobiDay* we decided to address the first issue by exploiting the knowledge of domain experts (the clinicians of the hospital) about the day hospital process. The core of the guidance service of *MobiDay* is a message–posting algorithm (see Section III-B) that is based on decision rules elicited from the clinicians. These rules are used to decide if a specific message should be generated for a patient given a specific context. The messages mimics common actions that the medical staff executes to guide the patients through the day hospital workflow. For example, when a patient has to be visited by a doctor after her blood analysis has been performed, a nurse invites her to move to the room dedicated to the medical examination. This human action is substituted by a decision rule that, given a patient in the described situation, generates a message like *"Please go to the medical examination, the doctor is waiting for you."* and sends it to the patient. The notification modality, i.e., how the patient attention is raised on new messages, is another delicate aspect. On one hand, phone ringing to exploit the auditory modality is not recommendable in a hospital. But on the other hand, we needed an effective way to attract the attention of patients. We decided to use a double notification mechanisms for the *high–priority messages*, i.e., those informing the patients about their next activity. These messages must be read immediately, i.e., before they become obsolete. In this case, we adopted the haptic modality (VibraCall) and a visual modality, consisting of an additional pop–up window on the display of the mobile device. Here the patient is requested to decide whether she wants to immediately read the message or delay this action.

Conversely, for *normal–priority messages*, which inform the patients about the current status of their hospital process, but do not require an immediate action, we decided to adopt only the haptic modality. Finally, we developed a simple and usable graphical user interface, exploiting the touch screen feature of a Nokia N97 smart phone. Touch screen offers a simple and direct interaction modality that is convenient also for non expert or impaired users [14].

B. Message Posting Algorithm

As we mentioned above, *MobiDay* repeatedly makes context–dependent decisions about which message should be delivered to the patient at the current time. From interviews with a domain expert (the head doctor of the unit) we identified three contextual factors as potentially relevant for the application scenario:

- the patient workflow step (retrieved from *ONCONET*);
- her location (given by the *RFID localization system*);
- the duration of the current step.

We decided to adopt a message–posting algorithm relying only on the workflow step, because the true influence of the other contextual factors were unknown. However, *MobiDay* logs the values of all the contextual factors, both when a message is sent by the server and when it is opened or closed by the patient. With the help of this information, the appropriateness of the messages in specific contexts could be analyzed offline.

The activities of a patient in the day hospital follow distinct patterns. Formally, the *ideal* patient workflow is simply a sequence of steps (or states)

$$START \Rightarrow WBA \Rightarrow BA \Rightarrow WE \Rightarrow E \Rightarrow WT \Rightarrow T \Rightarrow D$$

where

WBA:	Waiting for Blood Analysis	*WT*:	Waiting for Therapy
BA:	Blood Analysis	*T*:	Therapy
WE:	Waiting for Examination	*D*:	Dismissal
E:	Medical Examination		

The ordering of these steps cannot be altered as each step has the previous step as a prerequisite. Therefore, patients in the day hospital have to "walk through" this sequence. Repetitions of the medical treatments are excluded: there is exactly one blood analysis, one medical examination, and one therapy per day. Therefore, the message–posting algorithm is based on a posting function $PF : S \rightarrow M$ that – given a workflow step s – returns a message m to be pushed to the patient. The adopted posting function is defined extensionally as follows:

$$\begin{array}{ll} WBA \mapsto \text{W} & BA \mapsto \text{CBA} \\ WE \mapsto \text{WAR} & E \mapsto \text{CE} \\ WT \mapsto \text{WTP} & D \mapsto \text{GB} \end{array}$$

The application specific meanings of the messages are explained in Table I. It is important to note that the workflow step change, which is the required input to the posting function, is performed manually by the personnel using the *ONCONET* hospital information system. Therefore, when the workflow step of a patient is changed in *ONCONET*, this action effects the posting function. In order to partially prevent errors, the algorithm never sends the same message more than once.

Abbreviation	Message Description	Message Text
W	Welcome	Welcome. Please take a seat in the waiting room. A nurse will call you soon.
CBA	Call for Blood Analysis	Please go into the therapy room for blood collection. A nurse is waiting for you there.
WAR	Waiting for Analysis Result	You will be called for the medical examination when the analysis of your data has been completed.
CE	Call for Examination	Please go to room 2.610 for the visit. Dr. Mitterer is waiting for you there.
WTP	Wait for Therapy Preparation	The personnel of the pharmacy is preparing the therapy for you. After completion of the customized therapy you will be called by a nurse.
GB	Good Bye	Thank you for your cooperation. Please return the mobile device to the hospital staff.

TABLE I
GUIDANCE MESSAGES.

IV. Patient assessment of the guidance service

The usability of *MobiDay* and the performance of its guidance service were evaluated in a 4-month-long user study held in the oncological day hospital of Meran (South Tyrol, Italy). In the experiment, 20 patients (12 female, 8 male) where asked by the primary doctor of the oncological unit to use *MobiDay* during their visits to the day hospital. The ages of the patients ranged from 35 to 75 years (32% between 35 and 50 years and 68% between 50 and 75 years). 15% of them declared to own a touchscreen device and 35% declared to rarely use a mobile device. These patients were given a Nokia N97 phone equipped with the *MobiDay* client and used the system for two sessions (visits). At the end of the second session they were asked to fill a usability questionnaire. The survey, which is shown in Table II, is the standard CSUQ usability questionnaire [15] with some additional specific questions about the performance of the *MobiDay* guidance system. For each statement in the survey, the patient was asked to express a level of agreement using a Likert scale with values in the range from 1 to 5[3]. Statements $S_1 - S_{12}$ concern several aspects of the usability of *MobiDay* and were proposed to the patients in order to gather their opinion about whether or not the system can be successfully adopted in a day hospital. Statements $S_{13} - S_{15}$ are specific to the guidance service and are targeted to understand if it was effective in supporting the patients, if the guidance messages were considered useful, and if they were timely sent.

[3]The interpretation of the values is the following: *1=Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly agree*.

The results of the survey are summarized in Figure 3, which shows the average agreement with each statement, calculated over the answers of the 20 patients, as well as its standard deviation. The first important result to be noticed is that the patients are, on average, globally satisfied with *MobiDay* ($Avg(S_{12}) = 4.15$). By looking at specific usability aspects, we can note that patients are very satisfied with the learnability of the system ($Avg(S_3) = 4.4$) and with the comprehensibility of the provided information ($Avg(S_5) = 4.4$), the clear organization of the user interface ($Avg(S_7) = 4.35$), and the fact it is easy to find the needed information ($Avg(S_6) = 4.2$). Other positive features of *MobiDay* are its simplicity of use ($Avg(S_1) = 4.1$), especially in recovering from errors ($Avg(S_4) = 4.25$), and the attractiveness of its user interface ($Avg(S_8) = 4.25$). The least positive aspect of *MobiDay* is how much comfortable the patients feel when using the system. In fact, the specific statement S_2 in the questionnaire received the least level of agreement. This is a clear indication that the introduction of a new technology in the hospital has a cost for the patients. Even though the use of the single functions of *MobiDay* was not mentally demanding ($Avg(S_9) = 4.15$) or caused psychological pain ($Avg(S_{10}) = 4.1$), several patients reported, in the free comments of the survey, that they encountered some problems in the use of the mobile device. In particular, the participants noted from the burden of having to carry the mobile device and pay attention to the messages for all the duration of their hospital sessions (up to several hours). As far as statements $S_{13} - S_{15}$ (specific to the performance of the *MobiDay* guidance service) are concerned, we can first note that the system was on average rated as effective for the execution of the hospital activities ($Avg(S_{13}) = 4.15$). In addition, the content of the messages was considered helpful by patients, as indicated by $Avg(S_{14}) = 4.05$. This is a sign of the good design of the message content we made in conjunction with the clinicians at the hospital. Finally, we can note that message timing was not always perfect, as can be seen by the average response for S_{15} (3.85). This is the second worst value in the survey.

V. Discussion on design choices

The system evaluation presented in Section IV shows that the prototype guidance service provided by *MobiDay* was positively evaluated by the patients and this supports the conclusion that our design choices were good. However, there were also some problems with the system, especially regarding the timing of the message sending.

We hypothesized that this was less to do with the timing of the messages, but rather a consequence of the user not noticing the message when it arrived. The interaction log data show that sometimes large time gaps lapsed between sending and reading of messages. Further, participants indicated (in the comment fields of their usability surveys) that the VibraCall notification message was too weak to be easily perceived.

Secondly, we observed in the logs that sometimes the expert–based message–posting rules were too rigid: We observed in the logs that the sequence of workflow steps recorded for a patient occasionally did not fit the ideal sequence described in Section III-B. Therefore, it could have happened that an erroneous registration of the workflow step change performed by the clinicians in *ONCONET* caused the system sending a message not appropriate for the current context of the patient. In fact, it is important to highlight that when the recorder workflow is closer to the ideal sequence, then the recorder appropriateness of messages increases. We also performed an *ANOVA* test to establish whether the workflow step and the location have an effect on the frequency of appropriate messages. The conclusion was that the appropriateness was not influenced by these contextual factors. This suggest that basing the message posting mechanism on the workflow step was a good decision, even if we admit that the relatively small size of the log data prevent us from making a concrete conclusion in this direction.

S_1	It was simple to use *MobiDay*.
S_2	I feel comfortable using *MobiDay*.
S_3	It was easy to learn to use *MobiDay*.
S_4	Whenever I make a mistake using *MobiDay*, I recover easily and quickly.
S_5	The information provided by *MobiDay* is clear.
S_6	It is easy to find in *MobiDay* the information I need.
S_7	The organization of information on the screen of *MobiDay* is clear.
S_8	The interface of *MobiDay* is pleasant.
S_9	The use of *MobiDay* was not mentally demanding.
S_{10}	I was not insecure, discouraged, irritated, stressed, or annoyed while using *MobiDay*.
S_{11}	*MobiDay* has all the functions and capabilities I expect it to have.
S_{12}	Overall, I am satisfied with *MobiDay*.
S_{13}	I could execute my hospital activities effectively using *MobiDay*.
S_{14}	The messages I received from *MobiDay* were helpful for the execution of my hospital activities.
S_{15}	I received the message from *MobiDay* at the right time.

TABLE II
System usability survey.

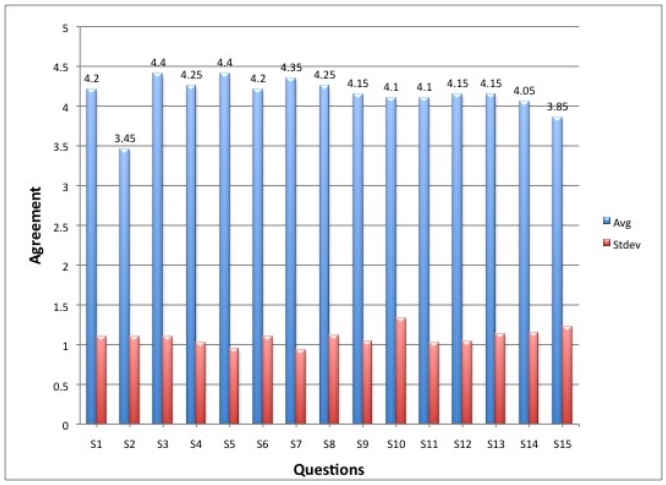

Fig. 3. Patient evaluation of *MobiDay*.

From the previous analysis we can derive the following guidelines for the development of a mobile guidance service for the patients in a day hospital.

- The selection of the notification mechanism for incoming messages is fundamental. It should be able to meet the need of not disturbing the other patients in a delicate environment as the hospital with the necessity of promptly inform the patient about important information that cannot be missed.
- If the messages become obsolete because they have not read, they should be deleted from the inbox of the mobile devices. In this way, no more misleading directions would be given to the patients.
- A message–posting algorithm based on rules defined in cooperation with the clinicians is a good baseline. However, it should be integrated with mechanisms supporting a more robust posting of the messages. This is needed to recover from possible discrepancies between the ideal model of the hospital processes elicited from the domain expert and the actual clinical practices.
- We observe that mobile applications are much harder to correctly design than desktop applications. Therefore, a robust mobile application for the day hospital tasks support cannot be developed in one single step. Several iterations are necessary to fully reveal all the relevant contextual factors in order to finally obtain an ergonomic design of the interaction that leads to an effective system.

VI. Conclusions

In this paper we have presented *MobiDay*, a novel multiple–function mobile application, integrated in the hospital information system, that supports patients and clinicians in the day hospital activites. Our systems provide patients with a guidance service that pushes messages informing them about their next activities to their mobile phones. In addition, mobile devices are employed to send patients questionnaires about their quality of life, which is useful to gather complete information about their health status. The main focus of the paper was on the *MobiDay*'s guidance service and its design choices. First, to notify the incoming messages using the haptic (vibration of the mobile device) and the visual (pop–up dialogs) modalities. Second, to base the decision about which guidance messages to send and when, on a set of static context–dependent rules elicited from the clinicians of the hospital. The user study we conducted with real patients of an oncological day hospital has shown that *MobiDay* is in general well accepted, although the responses to the usability surveys show that not all participants felt completely comfortable when using the system. *MobiDay*'s guidance service was evaluated as effective for the execution of the hospital activities. The content of the guidance messages was considered helpful by patients, while the timing of delivery was perceived as a relative weakness. The inspection of the system logs allowed us to conclude that our design choices for the guidance service are a good baseline. Nevertheless, a more effective notification mechanism should be adopted, as well as a more precise algorithm for message delivery. The system was also positively judged by clinicians, who expressed their satisfaction about *MobiDay*, especially as a tool for gathering useful information on patients' heath. As for future work, we intend to develop an enhanced and more robust version of *MobiDay*. In this direction, a first improvement is to design an adaptive workflow management component, which allows more flexibility in the workflow definition and execution. A second improvement is to move to a more user-friendly web-based architecture, that will allow the patients to use their own mobile phones without installing a dedicated application. This will also reduce the system comfortability problems highlighted by the conducted user study that are mainly related to the fact that the users had to learn to interact with a new device.

References

[1] J. E. Bardram, "Pervasive healthcare as a scientific discipline," *Methods of information in medicine*, vol. 47, no. 3, pp. 178–185, 2008. [Online]. Available: http://view.ncbi.nlm.nih.gov/pubmed/18473081

[2] C. Orwat, A. Graefe, and T. Faulwasser, "Towards pervasive computing in health care - A literature review," *BMC Medical Informatics and Decision Making*, vol. 8, pp. 1–18, 2008.

[3] S. V. Cantrill, "Computers in patient care: the promise and the challenge," *Commun. ACM*, vol. 53, no. 9, pp. 42–47, 2010. [Online]. Available: http://portal.acm.org/ft_gateway.cfm?id=1810907&type=digitaledition&coll=Portal&dl=ACM&CFID=105179573&CFTOKEN=60672122

[4] J. Kaye and T. Zitzelberger, "Overview of healthcare, disease, and disability," in *Pervasive Computiting in Healthcare*, J. E. Bardram, A. Mihailidis, and W. Dadong, Eds. CRC Press, 2007.

[5] P. Lamber, A. Girardello, F. Ricci, and M. Mitterer, "MobiDay: a Personalized Context-Aware Mobile Service for Day Hospital Workflow Support," in *Proceedings of the AIME09 International Workshop on Personalization for e-Health*, 2009, pp. 15–19.

[6] J. Bardram, T. Hansen, and M. Soegaard, "AwareMedia: a shared interactive display supporting social, temporal, and spatial awareness in surgery," in *Proceedings of the 2006 20th anniversary ACM conference on Computer supported cooperative work*. ACM, 2006.

[7] B. Skov and T. Hoegh, "Supporting information access in a hospital ward by a context-aware mobile electronic patient record," *Personal Ubiquitous Comput.*, vol. 10, pp. 205–214, March 2006. [Online]. Available: http://dx.doi.org/10.1007/s00779-005-0049-0

[8] T. Solvoll and J. Scholl, "Strategies to reduce interruptions from mobile communication systems in surgical wards," *Journal of Telemedicine and Telecare*, vol. 14, no. 7, 2008.

[9] "Java Platform, Micro Edition," http://en.wikipedia.org/wiki/Java_Platform,_Micro_Edition.

[10] EDP Progetti S.r.l., "ONCONET: Gestione Day Ospital del paziente oncoematologico," http://www.onconet.net.

[11] V. Meraner, J. Giesinger, G. Kemmler, S. Taucher, M. Hubalek, B. Weber, G. Rumpold, B. Sperner-Unterweger, and B. Holzner, "Development of a screening tool for the identification of psychooncological treatment need in breast cancer patients," *Psychooncology*, vol. 18, no. 9, 2009.

[12] "Questionnaire - quality of life," http://groups.eortc.be/qol/downloads/modules/specimen_20qlq_c30.pdf.

[13] R. Want, "An introduction to RFID technology," *IEEE Pervasive Computing*, vol. 5, no. 1, pp. 25–33, Jan-Mar 2006.

[14] T. Guerreiro, H. Nicolau, J. Jorge, and D. Gonçalves, "Towards accessible touch interfaces," in *Proceedings of the 12th international ACM SIGACCESS conference on Computers and accessibility*, ser. ASSETS '10. New York, NY, USA: ACM, 2010, pp. 19–26. [Online]. Available: http://doi.acm.org/10.1145/1878803.1878809

[15] J. R. Lewis, "IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use," *Int. J. Hum.-Comput. Interact.*, vol. 7, pp. 57–78, January 1995. [Online]. Available: http://portal.acm.org/citation.cfm?id=204770.204774