Guiding Patients in the Hospital

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Abstract. Automated patient guidance in a hospital can be a helpful service for non-hospitalized patients. In fact, they often need to move independently to reach locations where medical cares are provided. The provision of such a guidance service motivated the development of *MobiDay*, a mobile advisory system for patients. A live user experiment of *MobiDay* revealed some shortcomings that motivated the design of a new improved version that is illustrated in this paper. The new system focus on the usage of multiple and distributed user interfaces and on the exploitation of a workflow management system.

Keywords: Guidance service, mobile services, distributed interfaces, workflow management.

1 Introduction

Patients visiting a hospital may be involved in rather complex sequences of tasks and may be requested to independently to reach the location where medical cares are provided. This may pose problems to them, especially to those suffering from serious diseases or aged. Therefore, patients could benefit from using a personal electronic guidance service that provides support for the execution of hospital activities. For example, they can be instructed in their next task, informed about the location where that takes place, or notified of a possible delay.

The provision of such a service is addressed in the *MobiDay* research project [14, 15]. In this paper we first summarize the function of *MobiDay*, and we illustrate the results of the system evaluation performed in a clinic: the oncological day hospital of Meran (South Tyrol, Italy). Then, we describe and motivate the features of a new improved system, addressing three main requirements: (1) extend the guidance service to other clinical processes, in addition to the oncological day hospital; (2) provide guidance to a wider range of patients; (3) improve the robustness and effectiveness of the guidance service, overcoming the drawbacks of the first version of *MobiDay*. This new system, which is currently under development, is based on the use of multiple (including mobile) devices and distributed user interfaces. Moreover, it adopts a workflow system to model and properly manage general clinical processes. In this paper we discuss two interesting research issues: how to automatically generate the personalized guidance messages for the patients (given workflow execution patterns); and how to better exploit the combination of multiple information channels supported by the different devices.

2 *MobiDay*: day hospital activities support

MobiDay is a mobile application that supports patient activities in a day hospital process [15]. The system provides a guidance service pushing on the patients' mobile phones messages about their next tasks. Moreover, patients can fill out on their phones questionnaires on the quality of life: to gather comprehensive information on their health status [14]. We developed *MobiDay* for the oncological day hospital of Meran (South Tyrol, Italy). The users are patients periodically visiting the day hospital for examinations and treatments. The day hospital process consists of a simple sequence of three tasks, namely, *Blood Analysis*, *Medical Examination*, and *Therapy*, interleaved by waiting periods of unpredictable length. These tasks and waiting periods are the states of the patient's workflow.

The guidance service of *MobiDay* is accessible via a simple touch-based graphical user interface on a Nokia N97 smartphone. Textual guidance messages are sent to the phone when *MobiDay* recognizes a relevant situation. Message-sending rules, which are implemented on a server component, have been elicited from the clinicians by means of interviews, identifying the relevant situations of the day hospital process and the corresponding information messages. The notification of an incoming message is based on the haptic (vibration of the mobile device) and the visual (popup dialogs) modalities.

The usability of *MobiDay* and the performance of the guidance service were evaluated in a 4-month-long user study [15]. In the experiment, 20 patients were given a smartphone equipped with *MobiDay* and they used the system for two consecutive visits. *MobiDay* transparently logged all the message reading actions performed by the patients and sampled their feedbacks on the appropriateness of the messages by explicitly requesting the patients' opinions. After two visits, the patients were asked to evaluate the system usability by filling a standard questionnaire (CSUQ [16]) that we extended with some specific questions about the performance of the guidance service. This study showed that *MobiDay* was in general well accepted, although not all the subjects felt completely comfortable using the system. In particular, the guidance service was evaluated as effective, the content of the guidance messages was considered helpful by the patients, but the timing of the messages was not always perceived as appropriate. By inspecting the system logs we derived some explanations for this weakness:

- One third of the messages were read much later than when actually received, hence they were obsolete and not useful anymore. We conjectured that they were not noticed because of the selected notification mechanism, i.e., the vibracall. This was confirmed by some patients, who reported that the vibration of the smartphone was too weak.
- For some patients, the system recorded a sequence of activity steps that did not follow the correct order (i.e., *Blood Analysis*, *Medical Examination*, and *Therapy*). In fact, we discovered that this was caused by wrong state

changes made by the nurses. Because of this, some of the sent messages were not appropriate for the patient's situation.

3 *MobiDay 2*

The lesson learned from the evaluation of *MobiDay* and the goal of expanding the applicability of this system to a larger number of hospital scenarios motivated a new system design that focused on three main objectives:

1. Provide a single web-based access point to all the system services, namely: *clinical questionnaire filling* for the patient; provision of *personalized information and tips* on the patient's disease; and *guidance in the hospital* (discussed in this paper).
2. Support a collection of distributed user interfaces. This is aimed at extending the guidance service to a wider range of patients and at improving the convenience of the service, giving to the patients the choice of accessing the system with the preferred and more suited device and interface.
3. Adopt a workflow management system to model and manage a larger set of clinical processes. The goal is to extend the scope of the guidance service to other hospital units and to increase its robustness and tolerance to human errors.

Starting from these objectives, we have designed the logical architecture of *MobiDay 2* (not presented here for lack of space). In the rest of this section we will detail each objective and describe the status of its development.

3.1 Mobile web solution

MobiDay is a J2ME native application that must be installed on the phones used by the patients during their visit. Not all mobile phones support J2ME and therefore we provided the patients with special phones. But this forced the patients to use a new device and to learn how to use it. That decreased the usability of the system [14]. In order to overcome this problem and to enlarge the number of potential users, we have decided to design *MobiDay 2* as a mobile web application. It will be accessible via the standard web browser that is available on the patients' mobile phones, and also on many other types of devices (e.g., tablets, kiosks, and PCs). However, mobile web development is still at an early stage, and there is a large variability in the level of support for mobile web standards (e.g., CSS, or HTML5) in the available mobile web browsers [13]. For this reason, special techniques are required to adapt a mobile web application to multiple devices.

To address this issue, we have reengineered the *questionnaire* service to adapt to many classes of smartphones, tablet-like devices, and PCs. All the service web pages have been written in XHTML Mobile Profile; the most popular markup language for mobile devices. The web application reads, in the request headers, the device's user agent and then queries the Device Atlas database [4] to access the phone features, in particular, the display size. Accordingly to these features the web pages are rendered using 5 customized CSSs, each one adapted for a major class of device displays. A similar design solution will be adopted for the other services of *MobiDay 2*.

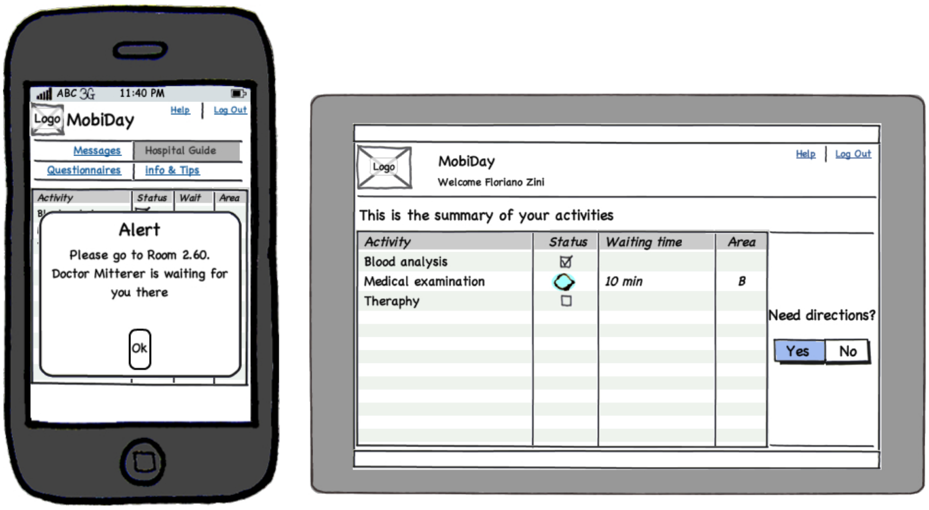
3.2 Distributed user interfaces

Distributed user interfaces is an active research area developing methods and technologies that allow users to interact with information systems via multiple devices and GUIs. Some research works (e.g. [10, 11]) have investigated the use of distributed interfaces for the coordination of the clinicians' activities in the hospital. To our knowledge, their usage for implementing guidance services for patients is still an unexplored field. In fact, the coordinated use of multiple communication channels is important to reach as many users as possible, by making the same information accessible in alternative ways and letting the user to select the most convenient one. In particular, several studies have been recently considered the combined use of mobile phones and wall displays in public places (see for example [8]). The focus of these research works was mostly on the interaction with a wall display in various public settings, using the mobile phone to obtain personalized information related to what is currently displayed.

In our application scenario public displays will be only used as output devices, for displaying anonymized information (e.g., Patient: P1, Room: 2.610, Waiting time: 5 min). Conversely, private mobile phones and kiosks (whose displays are not publicly visible) will be used to provide personalized details. We have designed the interfaces for public and private devices. For example, Figure 1 -(a) illustrates the interface for displaying messages sent to the patient's mobile, informing him about the next medical examination. Figure 1-(b) shows a view, displayed on demand on a kiosk, giving to a patient the status (either *done*, or *ongoing*, or *to-do*) of his activities in the hospital. We will support the patient interaction with mobile phones and kiosks using two modalities: autonomous access to the information about the patient hospital process; or browsing of the push messages sent (only) to the mobile.

3.3 Workflow management

The guidance service implemented in the first prototype of *MobiDay* was developed for an ad-hoc scenario. Actually, hospital processes are more complex: they are composed by tasks having various kinds of execution composition (e.g., sequential, parallel, or alternate); they involve many actors (e.g., patients, doctors, nurses, administration staff, or caregivers); they need to synchronize with other processes (e.g., the blood analysis process with the oncological day hospital process). A valuable patient guidance service should be based on the full model of the hospital processes. But, at the same time, this additional complexity must be hidden to the patients and exploited only to give them better and more precise information.



(a) (b)

Fig. 1. (a) Mobile with calling message; (b) Kiosk showing the patient's workflow status.

Business process and workflow management systems offer tools to deal with this complexity: (semi-)formal notations to represent the interplaying of hospital activities; engines for the controlled execution of workflows; automated logging of workflow execution; and, process mining to extract knowledge from event logs. The research on workflow management in healthcare is very active. Research works have been recently published on the modeling of hospital processes [18], on the dynamic compilation of web services to support workflow management in a hospital [9], on adaptive clinical workflows [19], on agents that monitor the patient's workflow and send alerts to clinicians [20], or on the application of process mining in healthcare [17].

We have selected the workflow management system to be introduced in *MobiDay 2*, considering the requirements that the tool must support the specific processes of the Meran hospital and must be suitable for the development of the guidance service. In particular, we were interested in a tool that:

- Provides messages as first class objects and support their management, e.g., program their conditional delivery. This helps in the definition of a message posting mechanism, more flexible and robust than the ad-hoc rule-based algorithm currently implemented.
- Can constraint the tasks in the workflow that are executed by humans. This, for instance, allows to prevent or at least to reduce the errors made in *MobiDay* by the nurses when changing the state of the patients. In practice, the GUIs used by the nurses to perform the state change must permit the activation of the patients tasks only, as it is illustrated in Figure 2.

– Can be extended in order to provide the automated generation of guidance messages, based on the workflow pattern followed by the patient. This point is expanded in Section 4.

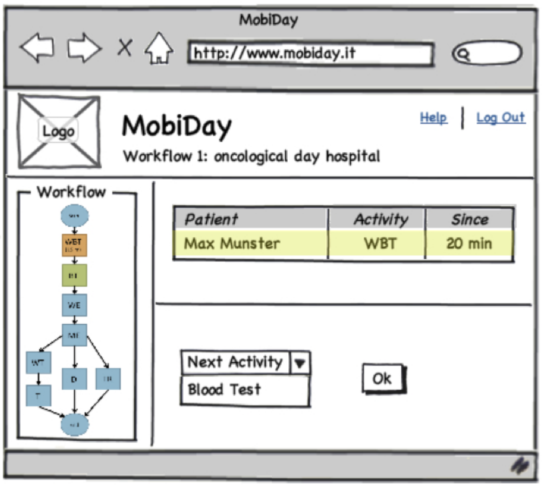


Fig. 2. Patient's next activity selection.

The workflow tools that we considered were jBPM [5], Activiti [1], BONITA [2], and YAWL [7]. The former three systems are commercial (even tough open source), while the latter is an academic research tool. From our evaluation YAWL appeared more complete: it has a formal semantics, provides full support for workflow patterns [6], allows to model workflows that are dynamically adaptable, and produces logs that can be inspected by process mining tools. On the other hand, the notation used to represent workflows is not standard and there is one single implementation. The other three tools use the standard BPMN 2.0 notation for workflow representation [3], have a wider community of users, and can be more easily integrated into information systems based on standard technologies. This latter consideration was decisive for the final choice of BONITA, as well as the fact that this system is being adopted in the hospital of Meran also for other projects.

4 Research issues

The design choices of *MobiDay 2* rise several research issues. Here we briefly introduce two interesting topics: how to automatically generate the guidance messages; and how to design a more effective and usable guidance service based on a human-system interaction via various devices and interfaces.

In *MobiDay* the content of the messages sent to the patient to notify a starting task was the same for all the patients. It is interesting to investigate how the system could automatically generate personalized calling message. A first knowledge content to be used in this personalization is the pattern followed so far by the patient in her clinical workflow. The personalized calling message for a specific activity could depend on this knowledge, i.e., according to the tasks that the patient has previously performed in the workflow. For example, the message could include an explanation of the reason why a specific examination or analysis is needed. Another dimension to exploit is the personal attitude of the patients towards the messaging service. Some patients could prefer, for the notification of the same task, messages structured differently. There are studies (e.g., [12]) that investigated how to generate personalized motivation messages that push users to conduct physical activities. We believe that similar techniques could be applied also for guidance messages.

Moreover, we hypothesize that a more effective and usable message notification service can be designed by exploiting multiple channels (devices and interfaces) for information provision. Obviously, to achieve that objective these channels must be suitably coordinated. Many coordination strategies can be envisaged: e.g., adaptively limit the use of the push interaction modality; or duplicate information on different channels; or provide complementary guidance data in selected interfaces. Various metrics can be adopted for measuring the effectiveness and usability. Effectiveness could be measured by monitoring the average difference between the time a calling message is sent and the starting time of the activity. The usability of the guidance service can be assessed by standard usability questionnaires, for example the CSUQ questionnaire adopted for the first version of *MobiDay*.

5 Conclusions

Automated guidance in the hospital is a significant service for patients who need support to reach the location of their treatments. In this short paper we have briefly presented *MobiDay*, a mobile application guiding patients during their day hospital process. We have illustrated some of its weaknesses that emerged from a filed user study. We have illustrated the major ideas for the design of a new improved version: *MobiDay 2*. First the adoption of a workflow management system to model and properly manage the clinical processes in the hospital. Second, the introduction of multiple and distributed user interfaces for offering guidance to a larger number of patients and for improving the effectiveness and usability of the service. The current status of development of *MobiDay 2* has been described. We have identified two main research issues. The first is related to how personalized guidance messages can be generated. It should be based on the analysis of the workflow patterns executed by the patients and adapting the notification strategy to the patient personal preferences. The second relates to the analysis of the most suitable strategies for the coordination and distribution of guidance information on multiple devices and interfaces, in order to maximize the overall usability and effectiveness of the service.

References

1. Activiti. http://activiti.org/.
2. BONITA. http://www.bonitasoft.com/.
3. BPMN 2.0. http://www.bpmn.org/.
4. Device Atlas. http://deviceatlas.com/.
5. jBPM. http://www.jboss.org/jbpm.
6. Workflow Patterns. http://www.workflowpatterns.com/.
7. YAWL. http://yawlfoundation.org/.
8. *CHI 2008 Workshop "Designing and Evaluating Mobile Phone-Based Interaction with Public Displays"*, Florence, Italy, 2008.
9. N. Prinyapol a. Fan and S. Kim Lau. A hospital based dynamic platform workflow management. *IAENG International Journal of Computer Science*, 36(2), 2009.
10. M. Bång, A. Larsson, E. Berglund, and H. Eriksson. Distributed user interfaces for clinical ubiquitous computing applications. *International Journal of Medical Informatics*, 74(7-8):545–551, 2005.
11. J.E. Bardram, T.R. 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.
12. F. Cortellese, M. Nalin, A. Morandi, A. Sanna, and F. Grasso. Personality diagnosis for personalized ehealth services. In *Proc. of the eHealth 2009 Second International ICST Conference on Electronic Healthcare for the 21st century*, 2009.
13. G. Rahn Frederick and R. Lal. *Beginning Smartphone Web Development*. Apress, 2009.
14. P. Lamber. MobiDay: a Personalized Context-Aware Mobile Service for Day Hospital Workflow Support. Master's thesis, Free University of Bozen-Bolzano, 2010.
15. P. Lamber, B. Ludwig, F. Ricci, F. Zini, and M. Mitterer. Message-Based Patient Guidance in Day-Hospital. In *Proceedings of MDM 2011 - 12th International Conference on Mobile Data Management*, Luleå, Sweden, June 2011.
16. J. R. Lewis. IBM computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. *International Journal of Human-Computer Interaction*, 7:57–78, January 1995.
17. R. S. Mans, M. H. Schonenberg, M. Song, W. M. P. Aalst, and P. J. M. Bakker. Application of process mining in healthcare – a case study in a dutch hospital. *Biomedical Engineering Systems and Technologies*, pages 425–438, 2009.
18. R.S. Mans, N.C. Russell, W.M.P. van der Aalst, P.J.M. Bakker, A.J. Moleman, and M.W.M. Jaspers. Proclets in healthcare. *Journal of Biomedical Informatics*, 43(4):632 – 649, 2010.
19. R.S. Mans, W.M.P. van der Aalst, N.C. Russell, and P.J.M. Bakker. Flexibility schemes for workflow management systems. In *Proc. of the 2nd international workshop on process-oriented information systems in healthcare : ProHealth'08*, 2008.
20. S. Uppu, D.B. Hoang, and T. Hintz. A mobile hand held computing system for out patient workflow in hospital environment. In *Proc. of. Vehicular Technology Conference*, 2006.