



Enhanced healthcare personnel rostering solution using mobile technologies



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ABSTRACT

This paper presents a novel personnel rostering system for healthcare units, which incorporates mobile technologies to minimize time overheads and boost personnel satisfaction. This way, doctors nurses and administrative staff may provide solutions and suggestions to the process of shifts' scheduling and rostering in a group based – social and organized manner, at any given time, using their smartphone or tablet. This system is designed and implemented according to wide research on requirements' specification, carried out in Greek public hospitals and based on a study of healthcare units' organization, at a practical and legal level. The personnel rostering system anticipates to facilitate the staff administration task, through real-time communication between hospital's personnel. It enables the formation of a micro-community with enhanced social communication tools, to provide dynamic management, recording and updating of changes that occur in scheduled duties, without mediators and delays. The proposed solution includes an intelligent mobile device application, designed for smartphones and tablets. It is provided to the personnel and enables them to participate in the process of scheduling duties and shifts. The XML based, back-end, supporting information system offers services that allow a smoother operation of the unit, minimize time overheads in case of arbitrary changes and maximize satisfaction of personnel. The overall operation of the units, that reclaim the features offered by this system, can be improved. Minimizing the time and other bureaucratic delays in personnel scheduling is a vital part of the way a healthcare facility is organized. Thus, facilitating this process, with any available technology, may prove to be cost effective and crucial. Systems that incorporate mobile applications are already widely accepted, and become increasingly important to the healthcare sector, as well. The mobile based, personnel shifts' scheduling solution shown is an approach that already receives encouraging support and indicates that it assists in achieving remarkable results.

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1. Introduction

Recent developments in telecommunications and information technology (IT) create a new environment of operation in healthcare facilities. Typical examples are wireless communications (for telecommunications) and portable computing devices (Personal Digital Assistants (PDAs), smartphones, tablets, etc.) for the IT sector. The term mobile computing, which in other business

domains had long been exploited, is a concept that in healthcare is still often misunderstood, but recently displays applications that show prospect for further exploitation. With the introduction of broadband Wireless Local Area Networks (WLANs) within hospitals and the large-scale adaptation of Hospital Information Systems (HISs) that can be used with portable computing devices, new opportunities are offered in process automation, reduction of costs and especially enhancement of the quality of services (QoSs), mainly through significant reduction of medical errors (Waterson et al., 2012).

On the one hand, Internet has broadened the scope of medical information systems and led to the development of distributed and interoperable information sources and services. At the same time, the need for standards became crucial. To treat patients, medical personnel can use different information systems in accordance to their needs, in order to diagnose and run tests. On the

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other hand, mobile devices have been embraced by everyone, causing an increasing number of healthcare professionals to utilize applications that enable remote monitoring or healthcare management. Numerous, easy to use mobile applications are already available and target different health problems and groups of people (Wiechert and Michahelles, 2007) and (Liu et al., 2011). However, healthcare units are extremely complex organizations, where personnel's scheduling is of great importance because it can affect the administration of the workload, quality of services and patient satisfaction. Establishing a productive way of creating duty rosters for the medical staff is very challenging, because it is subject to numerous factors, some of which are unpredictable.

In this paper we propose a solution with proper allocation of available resources and involvement of the personnel, with control over their schedules. Our approach is human-oriented putting the personnel in the centre of it. It takes advantage of the current explosion in smartphone adoption, for the case of medical personnel i.e. doctors and nurses. We have based our approach on systematic research on hospital staff requirements for an efficient rostering scheme. As a result we have designed, and implemented a specially focussed smartphone application coupled with an effective back-end information system to best serve medical staff needs and expectations for rostering management.

The main contributions of this paper are to introduce an approach that deals with lots of obstacles in day-to-day medical rostering management and allows for improved workflow in medical units as well as improved staff utilization. The key innovations of our approach are that (a) it allows health carers to get informed online and make ad-hoc changes to their shifts dynamically through smartphones and (b) keep in their smartphone a personalized calendar of their shifts that is populated by the hospital scheduling system using web services. In this way, two worlds are interconnected, (i) the hospital information systems and (ii) general purpose calendaring smartphone apps. To the best of the authors' knowledge, there are no HIS systems and calendaring applications with the proposed functionality.

A study of the existing, non-automatic administration systems for shifts and duties timetable was conducted in two major modern hospitals in Greece. The difficulties and problems that occurred, due to an insufficient staff scheduling process, were taken into account in order to design a system that offers services, which allow smooth operation of the unit and satisfaction of the people involved. For the development of the personnel rostering system presented in this work, we exploited modern web technologies which included programming in three different platforms. These technologies were used for developing an application for portable devices (smartphones and tablets), on the client side and for a Web based application, which administers the central database and arbitrates the system. Last but not least, a Web Service which enables wireless transaction between the applications and the databases was developed.

The rest of the paper is organized as follows: Section 2 discusses other approaches to this problem and related work. Section 3 describes the requirements analysis that was based on research of healthcare units' current way of functioning. Section 4 presents the implementation issues and the system components. Section 5 introduces extension capabilities of our system, for integration with existing rostering systems. Section 6 presents the experimental results and evaluation of the simulation outcomes. Finally, Section 7 concludes the paper and gives ideas for further research and future steps.

2. Previous works and related technologies

The use of mobile applications in healthcare has received much attention recently. Therefore one can easily discover a large number

of applications that serve different specialties and health issues. We often see use of individual mobile health applications, developed to serve specific purposes, in every major online market for mobile applications, including Android Market, Apple Store and Samsung Apps (Paschou et al., 2013a). There are applications which assist Cardiology by measuring blood pressure as well as numerous applications for diabetes, obesity, dementia and various chronic diseases (Mirza et al., 2008). Smartphones even work in conjunction with sensors and manage to detect tachycardia or even respiratory infections. During the last few years, several initiatives have proposed solutions to address different mobility related issues, towards ubiquitous m-health (Callegari et al., 2013). These issues include various domains, ranging from doctor mobility and remote access to medical data, patient mobility, with remote monitoring of vital signals to remote consultation, mobile medical and health record (Yahmed et al., 2013).

Personnel scheduling is a highly constrained and complex problem, thus finding good solutions to it is extremely difficult. Ideally, solutions must manage to minimize costs, meet employee preferences, distribute shifts equitably among employees and satisfy all the workplace constraints. In general, the unique characteristics of different units and organizations need specific mathematical models and algorithms to be developed for personnel scheduling solutions, in different areas of application. Thus, many of the proposed solutions include heuristic and simulation techniques. Early approaches addressed a number of problem formulations and solution techniques. A goal in many existing studies is to provide support tools to reduce the need for manual construction of rosters (Ernst et al., 2004).

In some other cases, the number of patients and their needs are taken into consideration, to determine the staff required as well as the corresponding skills. Puente et al. (2009) use an automated approach, by applying genetic algorithms in a hospital emergency department. Utilizing workers' requirements and defining the adequate encoding to use, a heuristic-schedule builder produces an initial population of feasible solutions. Afterwards, iteratively, the genetic algorithm obtains new generations of feasible individuals based in the exchange of whole work weeks that operates together with a repair function. A related problem is that of patients' scheduling in healthcare units (Vermeulen et al., 2009), where much work has been done as well, using similar techniques and approaches to the ones mentioned above (Hutzschenreuter et al., 2008) for adaptive resource allocation.

Scheduling staff shifts is a problem in the operation research field, thus it is often studied from the algorithmic point of view and rarely from the human-computer interaction perspective. The approach in Ardito et al. (2009), deals with automatic solutions that usually do not satisfy the people involved. Combining an expert system with an information visualization system, allows for last minute changes on the results, if necessary, by direct manipulation of the visualized data and immediate feedback about the changes made. There are mobile health architectures available for treatment compliance, data collection/disease surveillance, point-of-care support tools for health workers, disease prevention/health promotion and emergency medical response system (Kim and Song, 2013). However, none of the smart practices proposed in the related literature exploits smart phones towards the direction of rostering. The solution presented in this work presents a coherent integration of smart phones to the traditional architecture of personnel scheduling, in order to enhance this particular aspect of healthcare delivery.

3. Research and study of healthcare units

The issue of personnel scheduling is very demanding and often this task is appointed to one person that has to handle the

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