mPharmacy: A System Enabling Prescription and Personal Assistive Medication Management on Mobile Devices

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Abstract. The electronic management of drug treatment can provide means for prescription expenditure control as well as improve the medication process of patients and reduce the risk of adverse drug events. This paper presents the design and implementation details of a mobile platform based on Android OS that can be used for assistive medication management. The presented system is intended for physicians, pharmacists, health managers and patients, enabling not only medication prescribing but personalized treatment monitoring as well, which involves the issuing of alerts and reminders.

Keywords: mobile healthcare, prescription management, mobile medication, assistive application, Android OS.

1 Introduction

Electronic Prescribing and Medication Management has become an important component of the e-health care systems in ambulatory settings ([1] – [5]). Numerous studies report both financial [5] and patient safety benefits ([1], [6]) that may be achievable through the latter applications. The proper management of drug treatment is essential, since modern potent drugs are the cause of hospitalization in 10–16% of internal medicine cases and about half of those could be avoided [2]. Also, considering that the expenditure on drug therapy has been growing faster than any other aspect of health care in many countries ([4] – [6]) the proper control of medicine usage can facilitate in regulating unnecessary expenses. Computerized systems for drug treatment have advanced simultaneously with the development of electronic patient records. With the recent development of telematics, the electronic transfer of medical data has become more common and the good quality of drug treatment achieved with the latter systems may be extended outside the hospital. The use of mobile prescription-assistive technologies have also met great acceptance by medical personnel as

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indicated in related studies [14]. Electronic drug treatment has also been associated with the ability to perform medication management and assistance for patients with special needs. It is very common for the elderly or for patients with cognitive impairments (e.g. mild dementia) to neglect taking the appropriate medication on time or make errors during the drug treatment [20]. This paper presents mPharmacy (mobile Pharmacy), a mobile platform based on Android OS that can be used by physicians for prescribing drugs and monitoring patient treatment, pharmacists for implementing prescriptions, health managers for controlling expenses and patients for assistive scheduling of drugs reception. In this paper, we focus on the physician and patient modules, which implement the assistive mobile prescription concept.

2 Related Work

The concept of electronic prescription and medication management is not relatively new. Several platforms and systems ([8] – [13]) have been proposed in the literature for managing electronic prescription that can be either deployed within healthcare organizations or used individually by physicians. Most of the related work utilizes modern interfaces (standalone applications and/or web interfaces) for providing the essential access and management of the medical repositories. Electronic prescriptions can also be forwarded through wireless transmission to in-range pharmacies [8]. The majority of the latter systems are designed for deploying within healthcare environments ([11], [13]).

Regarding personal medication assistance, in [15] a medication reminding service in home environments and its context reasoning method is presented. In order to provide an appropriate medication service depending on the user's situation, authors model and infer the context based on user's condition. Authors in [16] assess the potential value of a home-centered medication reminder system. The system has been conceptualized as a system that uses a television and set-top box, mobile phones and other in-home accessories as a means to set and deliver medication reminders to the elderly. Similarly, in [17] medications are parsed and mapped into event taxonomies and then represented through appropriate displays in a timeline fashion. In [18] technological possibilities for implementing a mobile application to support medication management of elderly vision impaired people are discussed.

All the aforementioned systems address either prescription management or personal medication facilitation individually and do not combine information derived from drug prescription with proper dose and usage. The proposed mPharmacy platform is a novel system that enables both prescription and medication management on mobile devices utilizing the Android OS.

3 Tools and Methods

This section presents the basic tools and method used for enabling the mobile prescription and personal medication management through the mPharmacy system.

3.1 The Android OS Mobile Platform

Android has emerged as a new mobile development platform, building on past successes while avoiding past failures of other platforms. Designed to empower mobile software developers to write innovative mobile applications, Android is an open source platform, allowing developers to enjoy many benefits over other competing platforms. Touted as an innovative and open platform, Android is being positioned to address the growing needs of the mobile marketplace. Android offers an open source software development kit (SDK) that enables developers to utilize extensive and modern application programming interfaces (APIs). The latter provide full access to the mobile device's resources and allow screen drawing, user input, network access (i.e. through WiFi, Bluetooth, 3G), storage, media, graphics and even direct hardware access. Media APIs are available for both playback and recording of audio, video and still images. For storage, developers aren't limited to file-based APIs. SQLite is available for relational data storage, a preferences API is available for simple setting storage and applications can extend the data storage mechanisms available. The latter makes Android suitable for storing healthcare information since it can allow a more structural management of data locally, like prescriptions and medication information. Finally, native support by the SDK is provided for communicated with Web Services.

3.2 Communication through Web Services

Web Services are emerging as a promising technology to build distributed applications. It is an implementation of Service Oriented Architecture (SOA) [7] that supports the concept of loosely-coupled, open-standard, language - and platform-independent systems. The loosely-coupled features allow service providers to modify backend functions while maintaining the same interface to clients. Web Services are accessed through the HTTP/HTTPS protocols and utilize XML (eXtendible Markup Language) for data exchange. This in turn implies that Web Services are independent of platform, programming language, tool and network infrastructure. Services can be assembled and composed in such a way to foster the reuse of existing back-end infrastructure.

Web services provide several technological and business benefits, a few of which include application and data integration, versatility, code re-use and cost savings. The inherent interoperability that comes with using vendor, platform and language independent XML technologies and the ubiquitous HTTP as a transport mean that any application can communicate with any other application using Web services. Web services are also versatile by design. They can be accessed by humans via a Web-based client interface, or they can be accessed by other applications and other Web services. Code re-use is another positive side-effect of Web services' interoperability and flexibility. One service might be utilized by several clients, all of which employ the operations provided to fulfill different business objectives.

4 Proposed System Architecture

This section presents the proposed architecture and the major components of the system that enables the mobile prescription and medication management. As illustrated

in Fig. 1, the mobile application consists of two major modules. The physician module that provides all the essential functionality for creating a prescription and the patient module that acquires prescriptions from the system and manages medication through reminders and dose information provision respectively. A local database within the mobile environment is used in order to store and retrieve important information like the submitted prescriptions by a specific physician user or the current drug list that corresponds to the medication prescribed to a patient user. A Web Services Client module provides common functionality to the aforementioned modules for retrieving and uploading information regarding medication and prescription. All the latter modules are hosted by the Android Operating System that runs on the mobile device. The interface for proper data management is implemented through a Web Service that communicates with appropriate database systems hosting prescription and medicine repositories. The Web service implements all the necessary functionality for performing queries in the database based on requests by user for medicines and prescriptions as well as insert new prescriptions into the database created by physicians. A public web-based interface can provide additional access to the information residing into the database and similar functionality. The latter can serve as an alternative portal to manage healthcare information and can be especially utilized by pharmacists in order to acquire and update the submitted prescriptions.

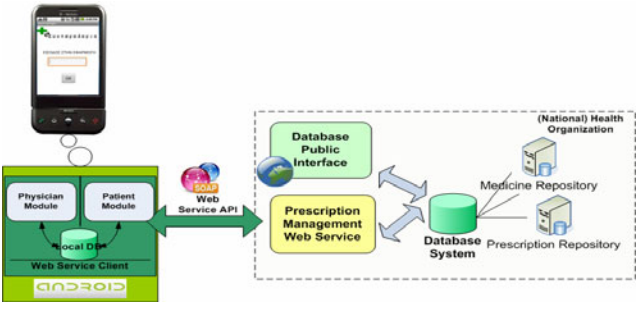

Fig. 1. Illustration of the proposed architecture

5 Mobile Prescription and Medication Management

The main features and processes of the mobile prescription and medication management system are discussed in this section. User access to both physician and patient modules is controlled through appropriate authentication mechanisms. Physicians are authenticated online through credentials that reside on the main database system and are provided only by proper registration. Patients can use credentials that are created and reside locally at the mobile system. Physicians can browse on line the medicine repository and select the appropriate medication based on pathology and retrieve additional information about dose and packaging. Once the appropriate medication is selected, physicians can enter dose and accompanying instructions through appropriate forms (see Fig. 2). The prescription is submitted into the online system and a unique identifier is assigned to each prescription. The latter along with the prescription information is also stored locally, so that it can be retrieved later by the physician.

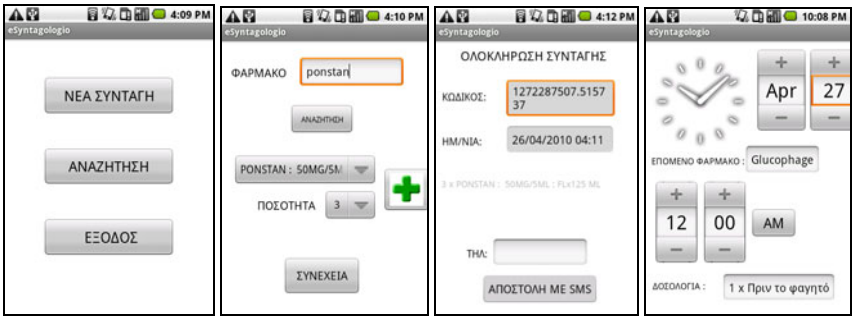

Fig. 2. Screenshots of the mobile application modules featuring main menu screen for physicians, medicine queries, prescription compose and medication management. Text messages are displayed in Greek.

Fig. 2 contains sample screenshots from the physician and patient mobile application modules respectively.

The assigned prescription id can be forwarded by the physician to a patient's mobile phone through text messaging. Patients can use the appropriate mobile application module and retrieve their personal medication list using the provided prescription id. The list contains useful information regarding dose and treatment. A scheduler embedded into the patient application module acts as a reminder for appropriate and on time medication.

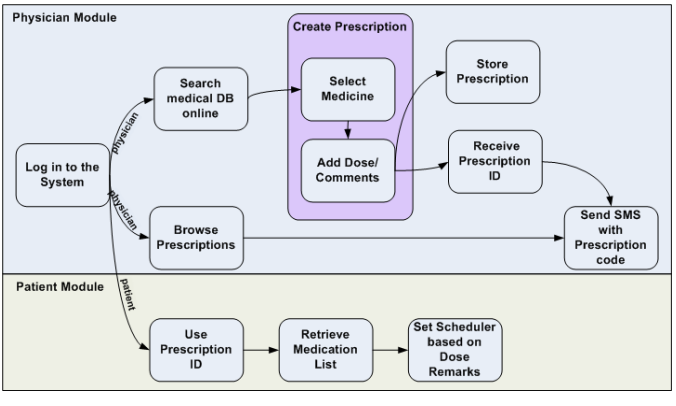

Fig. 3. Data Flow Diagram of the physician prescription management and patient medication module

The process of creating and managing prescriptions from physicians and managing medication from patients is illustrated as a data flow diagram in Fig. 3.

Enabling access to web services along with the advanced wireless connectivity options provided by the Android platform (Bluetooth, WiFi, 3G), the mPharmacy system can easily be integrated with additional external medical information platforms. Collaboration with electronic medical record systems can provide instant and direct

mobile access to patient history allowing physicians to take better decisions regarding treatments. Adverse situations can be avoided when allergies on special drugs are taken into consideration. Furthermore, the integrated patient module can easily communicate with smart devices that assist and control medication, like the SmartDrawer [19].

6 Conclusions

Mobile prescription systems and personal medication assistance are promising technologies for addressing financial and personal safety issues that have raised with the current drug treatment process by medical personnel. The proposed mPharmacy platform is a novel system that enables both prescription and medication treatment assistance on mobile devices. Legal, ethical, standardization and interoperability issues need to be resolved before such mobile platforms can be deployed in real environments assisting the management of drug treatment and the medication process. However the proposed implementation proves the feasibility of mobile prescription and assistive medication management systems and exhibits the benefits of such systems.

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