Mobile Healthcare Systems: Generating Dynamic Smartphone Apps to Serve Multiple Medical Specializations

Assisting Monitoring Patient@Home and Health Record Follow-up

Mersini Paschou, Nikolaos Nodarakis, Athanasios Tsakalidis and Evangelos Sakkopoulos
Department of Computer Engineering & Informatics, School of Engineering
University of Patras, Rio Campus, 26500 Patras, Greece

Keywords: Mobile Technologies, Healthcare Applications, Smartphones, Health Care Management, Health Information Systems, Wireless Technology.

Abstract: During the recent years mobile devices and especially smartphones have been embraced by a rapidly increasing number of people worldwide. In fact, this trend is expected to evolve even more in the years to come. One of the many fields of their utilization is the health domain, with numerous applications that record critical medical data and communicate with other applications in an effort to solve a single health issue each time. However, these applications demand time and effort for maintenance, both from developers and users. In this work we propose, design and implement a single solution which gives healthcare researchers and professionals the ability to create smartphone applications on the fly, regardless of the desired healthcare content that has to be recorded. The proposed approach applies efficient techniques for development and is based on dynamically receiving business and UI at the first time of application download.

1 INTRODUCTION

Smartphone applications are receiving rapid acceptance and wide distribution with the release of radically increasing number of smartphones and respective platforms. This event makes mobile technology more attractive for new and further penetration into e-Health, with numerous applications available currently, which target different health problems and groups of people. These applications use the limited resources that are provided by mobile devices, compared to desktop systems. However, by seizing a number of advantages such as portability, Internet access, location detection services etc. these applications quickly became very popular and an integral part of everyday life. (Kao et al., 2012)

An increasing number of healthcare professionals put into use smartphones' applications that enable remote monitoring or healthcare management. Moreover, lots of patients already take advantage of m-health applications to improve and assist their own life and health (Global Mobile Health Market Report 2010-2015). Although the benefits of m-health applications are positive and quite promising, much is yet to be done in the particular domain to make it even more successful and wide-spread (Paschou et al., 2012). In this work we discuss how most existing applications that meet the needs of individual specialties in healthcare & medicine and function in similar ways, can become easier to develop, maintain and customise. We present a novel and efficient smartphone apps generator. The proposed solution gives healthcare researchers and professionals the ability to create data intensive unique smartphone applications just through a single system.

The rest of the paper is organized as follows: Section 2 discusses related work. The proposed system architecture and functionality are presented in Section 3. Section 4 introduces data entry applications as approximated for the purposes of this work. Section 5 describes related technologies and Section 6 presents an evaluation based on comparing available mobile health applications with the respective ones created with the presented tool. Finally, Section 7 concludes the paper and presents future steps.

Paschou M., Nodarakis N., Tsakalidis A. and Sakkopoulos E..
Mobile Healthcare Systems: Generating Dynamic Smartphone Apps to Serve Multiple Medical Specializations - Assisting Monitoring Patient@Home and Health Record Follow-up.
DOI: 10.5220/0004237302150220
In *Proceedings of the International Conference on Health Informatics* (HEALTHINF-2013), pages 215-220
ISBN: 978-989-8565-37-2

2 RELATED WORK

Handheld devices have been exploited in many cases to facilitate health oriented procedures. M-health and can be defined as "mobile computing, medical sensor, and communications technologies for health-care". This emerging concept represents the evolution of e-health systems from traditional desktop "telemedicine" platforms to wireless and mobile configurations. (Altini et al., 2010)

Developments in wireless communications integrated with developments in pervasive and wearable technologies will have a radical impact on future health-care delivery systems. (Istepanian et al., 2004) Mobile applications solutions are becoming increasingly popular because they can be used by a great number of people and target different health issues or groups of patients (Karan et al., 2012).

Ambulatory health care offers an effective means of bringing healthcare services to people all over the world. With low-cost handsets and the penetration of mobile phone networks globally, tens of millions of citizens, even those ones that never had regular access to a fixed-line telephone or computer, now use mobile devices as daily tools for communication and data transfer (Lytras et al., 2009)

There are numerous apps available, for any possible need, from counting calories and nutrition information (Silva et al., 2011), logging fitness workouts (Fujiki, 2010), monitoring vital signs or provide health tips, apps that calculate disease risks and body mass index. (Krejcar et al., 2009) Application for keeping personal health records are numerous, as well, some provide users' health information to physicians or emergency workers. (Orphanidou et al., 2009) Tips for smoking cessation or for yoga stretching exercises, detailed information about medicines (Silva et al., 2009), is only a small subset of the tasks people can perform using Apps. (Fox, 2010)

Many consumers nowadays take advantage of m-Health applications to improve their lives and assist their health. Benefits of m-Health Applications and Solutions are widely known and accepted. Many existing applications meet the needs of individual specialties in medicine (Chemlal et al., 2011) and work in similar ways, whether they are stand-alone applications or they work online. These applications usually have common characteristics; they record critical medical data and communicate with other applications in an effort to solve a health issue. (Klug et al., 2010) In this paper, we present an open and versatile solution to ease the development of data recording mobile applications for almost any kind of medical specialization.

3 SYSTEM FUNCTIONALITY AND ARCHITECTURAL COMPONENTS

Most of the existing applications meet the needs of individual specialties in medicine and work in similar ways, whether they are stand-alone applications or they work online using Wi-Fi, LAN or Internet. Most healthcare Smartphone applications have common characteristics; they record critical medical data and communicate with other applications in an effort to solve a single problem each time. Moreover, they demand much time and effort to meet the needs of patients and experts at any given time. As a result, a strong need for re-usability driven implementations stems from the demand for a continuous software update on users' smartphones.

The proposed approach applies efficient techniques for development and is based on dynamic reception of business logic and UI at the first time of smartphone application download. In this way, we propose removing the healthcare business logic part from the mobile client application itself and making it possible to be managed and configured in a versatile manner remotely. The application is designed to support patients at home and assist the physician by recording information about treatments and results of medical tests and measurements (e.g. measuring blood pressure, etc.), without the current overhead of continuous maintenance and by exchanging messages with a format based on XML (Extensible Markup Language).

3.1 System Components

Before discussing on the review performed to choose the different data components that it is possible to include in a produced App, the system components that make the solution functional are presented. The proposed solution consists of a web interface for the application design, some internet services and a client application for mobile devices in Android environment.

The system administrator designs the layout and functionality of the application, using the web interface. The result becomes available to the client application through an Internet service that produces a configuration file. The client application is respon-

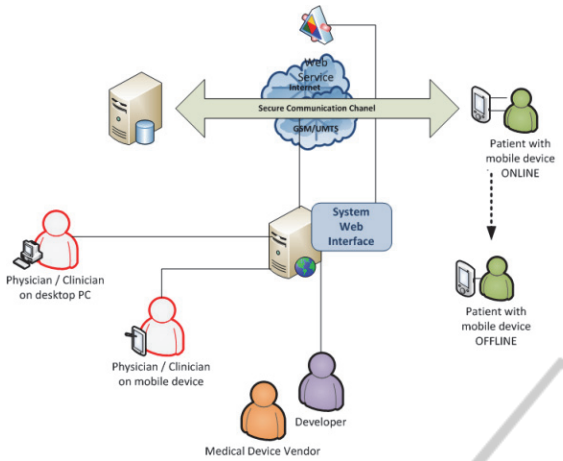

Figure 1: Proposed system's overview.

sible for translating the file and displaying the final application to the user.

3.2 System Application Functionality

Through the proposed solution we address and solve the above issues. Using the proposed approach (Figure 1) it is easy to deliver e-Health Apps for biomedical data collection and health metrics recording for any medical specialty in an automatic way. The applications that can be designed and implemented by the system belong to the data-entry category, which covers the vast majority of the smartphone apps as we have seen in the related work section.

The functionality of the proposed solution is further analyzed in more detail here. The proposed solution allows the users of the system (doctors and designers) to navigate to the management page and enables new users to enrol. After logging in, the App designer views the page with the applications that have already been created and may choose to create a new application, update or permanently delete an existing one. Furthermore, the user has the option to disconnect from the system. When creating a new application the user must choose the fields he/she wants for the forms of the application and add them.

Each field that has been added to the form may be modified or deleted. The user can create up to eight forms. This is the maximum number of different forms appearing to the majority of related Apps available online. The limit is provided to keep the final Apps simple and user friendly and has nothing to do with the capabilities of the system itself. Once the above procedure is over, two more steps are required to complete the application design.

The user must enter the App title and a splash screen image that will appear when the smartphone Application loads. The title/name of each application must be unique. From this moment on, it is possible for the doctor to invite patients to download the App from the respective App store/market in order to start using it

3.3 System Architecture

The system is composed of four parts: 1) the mobile device application, 2) Web services which serve the calls from the mobile device application, contact the database and return the appropriate response, 3) the database, which contains the structure and functionality of applications and 4) the web interface, which is used for designing the application. The database, web interface and Web services are part of the web system.

4 DATA ENTRY HEALTH MOBILE APPS

Usage of mobile, handheld, computing devices constantly expands, with smartphones, cellular phones, personal digital assistants (PDAs), and pagers supporting an ever increasing array of activities. To support these activities, systems provide a variety of text-entry techniques. Alternatives include stylus-activated soft keyboards (e.g. a small QWERTY keyboard presented on a touch-sensitive screen), small physical keyboards, stylus-based gesture recognition (e.g. Jot and Graffiti), and telephone keypad-based techniques (e.g. T9). (Sears and Arora, 2002)

The applications that address health issues belong to the data-entry category in their majority. For the sake of this work we have studied a number of health related applications, available at well-known e-markets and recorded the type and number of their controls. The most common types of controls that are used, according to the results of this survey procedure, include TextViews, EditTexts, RadioButtons, Buttons, ImageViews and Spinners. With this process, we chose the set of controls that we incorporated in the system presented, for the development of healthcare applications on the fly. The user of the system can choose any one of these controls to include them in her/his application and customise it according to the respective needs.

5 RELATED TECHNOLOGIES

For the web part of the system an HTTP server and MySQL database to store all information related to applications are required. The application server used is Apache. The web interface was created using the open source tool, PHP CodeIgniter. The web programming language used is PHP and the technologies HTML5, CSS3, JavaScript, AJAX and jQuery were used as well. jQuery is a fast and concise JavaScript Library that simplifies HTML document traversing, handling events, creating animation and interactivity with AJAX technology for rapid development of Internet applications.
To create the Web services that use the REST model, a respective plug-in for CodeIgniter was used. For the development and simulation of the client application on the device the typical ADT (Android Development Toolkit) plug-in was used.

5.1 Data Transfer

The representation of a resource reflects its current status, and traits, at the moment a client application is making the request. They can be considered to be snapshots of information in time. A simple example is the representation of a record in a database, consisting of mapping columns names and XML tags of an XML file, where the value of each label is the corresponding value in the column of the entry. The restriction imposed by the architecture of RESTful Web services is related to the format of the data exchanged between the application and the service. It is very important for the format of the information to be simple and easy to understand by humans. Hence for the transfer of data XML and/or JSON format are used.

5.2 REST Model

Mobile health applications must be easy to create, deploy, test and maintain, and they must rely on a scalable and easily integrated infrastructure. (Andry et al., 2011) A Representational State Transfer (REST) API integrated with a mobile application that offer physicians access to their patients' health records meets those needs.

REST model defines a set of architectural principles that allow designing Web services that focus on system resources and how they are represented and transferred over HTTP protocol in a variety of different clients. The number of Internet services that use REST model has grown exponentially in recent years and have rendered it to be the dominant model in the area, having almost completely replaced SOAP, as its functionality is considered simpler and easier to understand.

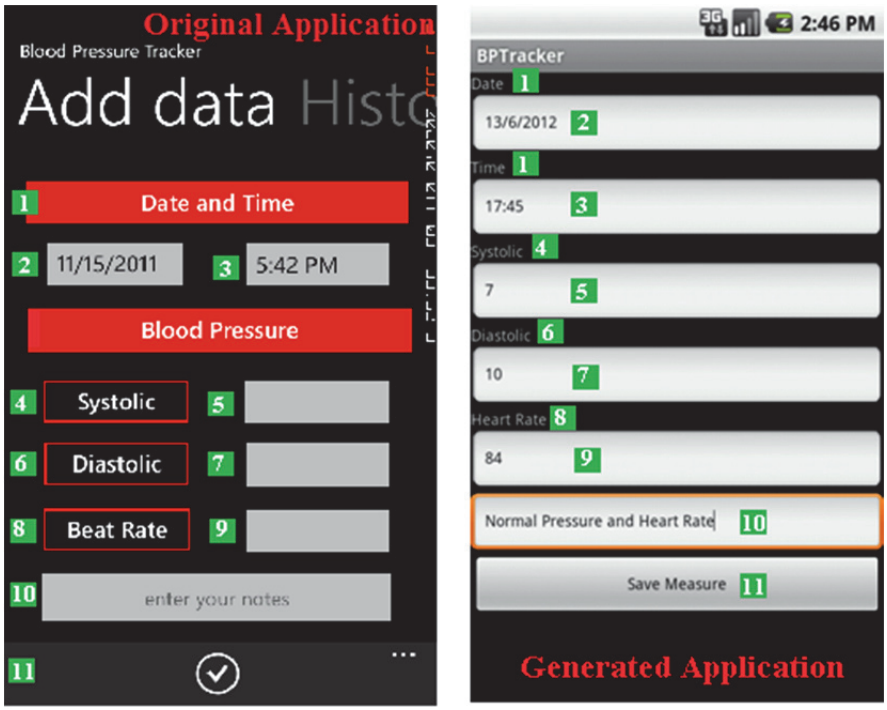

Figure 2: Comparison of blood pressure values recording forms.

6 EVALUATION AND RESULTS

There is a great number of health Smartphone Apps that may be designed and produced by the proposed mechanism automatically. For example a cardiologist's Smartphone App can be easily produced using our system to record blood pressure (systolic, diastolic and beat rate) data according to a schedule proposed by the patient's doctor. Moreover, a different Smartphone App to record allergic reactions may be designed by allergiologists easily to assist patients to record the severance level, the symptom type (e.g. tears, asthma etc) of allergic reactions. Our approach does not need any coding at any programming language and it can be easily used directly by doctors, though the collaboration with a Smartphone App designer, a graphics expert or a programmer can prove to be useful and improve the functionality of the final App developed.

For evaluation purposes, we have recreated existing applications using our solution and perform comparative experimentation with each other to show that the proposed solution outputs the same functionality and ease of use Apps with no programming at all just through the web UI of the proposed solution. In this section a native application for android mobile devices is presented and compared with the one developed using the presented system and has the same functionality.

The comparison is carried out both at functional level as well as for issues related to the GUI. The application used for this purpose is called Care@HOME and is a mobile monitoring system for patient Treatment and Blood Pressure Tracking. (Paschou et al., 2012) Through the respective controls in the forms presented in Figure 2 date and time of measurement can be selected and values of systolic and diastolic pressure can be registered. All controls of the application have been rendered automatically. This included *textview* controls (e.g. no. 1,4,6,8), *edittext* controls to insert data for logging (e.g. no 2,3,5,7,9,10), *button* (e.g. no 11) and of course the *form* itself with its *title* name. For other applications under examination, we also observed that all different controls are rendered correctly and efficiently.

Overall the proposed solution has received encouraging feedback from doctors in a number of healthcare units in Greece and proves to be effective in delivering end-user Smartphone application with practically minimum development effort. In this way it allows healthcare researchers and professionals to deliver an efficient Smartphone app in order to assist patient monitoring and follow-up research.

7 CONCLUSIONS AND FUTURE WORK

Using the integrated system developed and presented in this work, physician patient interaction is enhanced, allowing exchange of data and information flow between them. An important issue to be addressed is effective policies for sending and receiving data to minimize the cost and volume of data for users. Application data related to health records will be sent to servers storing personal health record service or directly to physicians. The implementation could apply alternative network connections of mobile applications to Web services and compare them in order to examine how the volume of data changes, etc. depending on the send / receive data protocol.

One important aspect of health related data is their security. Many applications for mobile devices make use of technical positioning (e.g. GPS or triangulation via GSM). To protect the privacy of users from insidious acts, techniques to protect anonymity of the position will be implemented. This will be achieved by the use of position anonymisation system in seeking information and services, based on location from point to point of interest for optimizing markets for mobile devices using external and heterogeneous data sources.

ACKNOWLEDGEMENTS

This research has been co-financed by the European Union (European Social Fund – ESF) and Greek national funds through the Operational Program "Education and Lifelong Learning" of the National Strategic Reference Framework (NSRF) - Research Funding Program: Heracleitus II. Investing in knowledge society through the European Social Fund.

REFERENCES

Altini, M., Penders, J., & Roebbers, H. (2010). An Android-based body area network gateway for mobile health applications. *WH '10 Wireless Health*, pp. 188-189.

Andry, F., Wan, L., & Nicholson, D. (2011). A Mobile Application Accessing Patients' Health Records through a REST API - How Rest-style Architecture can Help Speed up the Development of Mobile Health Care Applications. In Vicente Traver, Ana L. N. Fred, Joaquim Filipe & Hugo Gamboa (Eds.), *Proceedings*

of HEALTHINF 2011 (pp. 27-32). SciTePress.

Chemlal S., Colberg S., Satin-Smith M., Gyuricsko E., Hubbard T., Scerbo M.W., & McKenzie F.D. (2011). Blood glucose individualized prediction for type 2 diabetes using iPhone application. *Bioengineering Conference (NEBEC) 2011* (pp. 1-2). IEEE 37th Annual Northeast.

Fox, S. (2010). Mobile Health 2010. Pew Research Center's Internet & American Life Project. http://pewinternet.org/Reports/2010/Mobile-Health-2010.aspx (accessed May 2012)

Fujiki Y. (2010). iPhone as a physical activity measurement platform. *CHI EA '10. Proceedings of the 28th of the international conference extended abstracts on Human factors in computing systems, pp. 4315-4320.*

Istepanian R, Jovanov E, Zhang YT., Guest Editorial. (2004). Introduction to the Special Section on M-Health: Beyond Seamless Mobility and Global Wireless Health-Care Connectivity. *IEEE Transactions on Information Technology in Biomedicine, Vol. 8, No. 4.*

Karan, A., Bayraktar, C., Gümüskaya, H., Karlık, B. (2012). Diagnosing diabetes using neural networks on small mobile devices. Expert Systems with Applications, pp. 54–60.

Kao, Y.-W., Lin, Ch., Yang, K.-A., Yuan, Sh.-M. (2012). A Web-based, Offline-able, and Personalized Runtime Environment for executing applications on mobile devices. Computer Standards & Interfaces 34, pp. 212–224.

Klug S., Krupka K., Dickhaus H., Katus H.A., Hilbel T. (2010). Displaying computerized ECG recordings and vital signs on Windows Phone 7 smartphones. Computing in Cardiology, pp. 1067-1070.

Krejcar, O., Janckulik1, D., Motalova, L. and Frischer, R. (2009). Architecture of Mobile and Desktop Stations for Noninvasive Continuous Blood Pressure Measurement. WC 2009, *IFMBE Proceedings 25/V, pp. 137-140.*

Lytras, M., Sakkopoulos, E., Ordóñez de Pablos, P., (2009). Semantic Web and Knowledge Management for the health domain: state of the art and challenges for the Seventh Framework Programme (FP7) of the European Union (2007–2013), *International Journal of Technology and Management (IJTM),* Inderscience Publishers, Vol. 47, No.1/2/3, pp. 239 - 249.

Orphanidou, Ch., Clifton, D., Khan, Sh., Smith, M., Feldmar, J., & Tarassenko, L. (2009). Telemetry-based vital sign monitoring for ambulatory hospital patients. *31st Annual International Conference of the IEEE EMBS*. Minneapolis, Minnesota, USA, September 2-6.

Paschou, M., Sourla, E., Basagiannis, G., Sakkopoulos, E., Tsakalidis, A., (2012). Care@HOME: A Mobile Monitoring System for Patient Treatment and Blood Pressure Tracking. Information Technology in Bio- and Medical Informatics Lecture Notes in Computer Science, 2012, Volume 7451/2012, 69-83,

Paschou, M., Sakkopoulos, E., Sourla, E., Tsakalidis, A., (2012). Health Internet of Things: Metrics and methods for efficient data transfer, Simulation Modelling Practice and Theory.

Sears A., Arora R. (2002). Data entry for mobile devices: An empirical comparison of novice performance with Jot and Graffiti Interacting with Computers, 14 (5), pp. 413-433.

Silva, B., Lopes, I., Rodrigues, J., Ray, P. (2011). SapoFitness: A Mobile Health Application for Dietary Evaluation. *IEEE 13th International Conference on e-Health Networking, Applications and Services.*

Silva, J. M., Mouttham, A., El Saddik, A. (2009). UbiMeds: a mobile application to improve accessibility and support medication adherence. *MSIADU '09 Proceedings of the 1st ACM SIGMM International workshop on Media studies and implementations that help improving access to disabled users. pp. 71-78.*

RESTful Web Services: The basics http://www.ibm.com/developerworks/webservices/library/ws-restful/ (Accessed 24 May 2012)

Global Mobile Health Market Report 2010-2015, http://www.research2guidance.com/ 500m-people-will-be-using-healthcare-mobile-applications-in-2015/ (Accessed May 2012)