Managing Healthcare in Hospitals using Ubiquitous Computing Concepts

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Abstract

The inefficiency of the healthcare sector in Brazil can be reinforced by the current use of Information and Communication Technologies (ICT) in health providers. A factor that corroborates with this statement is that only a quarter of those providers employ fully electronic health records. In this way, we propose uHospital, a model to manage healthcare in hospitals. The focus is on the Electronic Health Record (EHR) using the concepts of mobile and ubiquitous computing applied to the health area. These ideas have been defined by the scientific community using two denominations: ubiquitous health, the monitoring of patients health anywhere and anytime, and ubiquitous healthcare, convenient services to patients that allows the clinical diagnosis. To employ these concepts, the model proposes the development of a Personal Health Record (PHR), storing all individual information related to a person's health. This PHR should include exams, diagnoses and also data inserted manually. One possibility in this area, from the popularization of mobile devices and the growth of body sensors use (wearable computing), is to allow people to interact with their PHR, using tablets and smartphones, combining the stored information in their health record with vital signs that have been constant monitored. Particularly, this project proposes the use of situation awareness to combine the patients context, including data being constantly monitored, with information already available in their electronic health record. To fulfill this goal, uHospital employs ontologies based on international and established healthcare standards. In this way, the proposed model allows the management of ubiquitous healthcare in hospitals, centered in a PHR, which permits the inference of patients risk situations.

1. Introduction

The Brazilian healthcare sector is inefficient in a general sense. One of the factors that reinforce this affirmation is the lack of sufficient hospitals to provide good quality service for the population. According to IBGE[1], Brazil had in 2009 2.26 hospital beds per thousand inhabitants, a ratio that has been decreasing in the last 20 years (in 1990 the ratio was 3.71 hospital beds per thousand inhabitants). One obvious alternative would be to build more hospitals or increasing the number of hospital beds in existing establishments. Another way would be to invest in Information and Communication Technology (ICT) in order to improve the efficiency in hospitals.

Just to give an idea of the current situation of ICT in Brazilian healthcare establishments, lets take a look at a survey conducted by the Center for Studying Information and Communication Technology (Cetic.br) in 2013, named TIC Saúde[2]. One factor to demonstrated the inefficiency in terms of ICT in Brazil was that only 25% of health establishments had totally electronic health records for storing patient's information. Furthermore, 9% of all hospital did not had at least Internet access in 2013.

Although this was observed in Brazil, internationally the use of some form of electronic health record for storing patient's information has been used in hospitals in the last years. The industry of Electronic Health Record (EHR) grew 15% in 2012, being estimated in 20.7 billion dollars [16]. However, in the same year, one survey had shown that 39% of physicians did not recommend the EHR they usually use to their colleges [16].

Among the main problems in the current EHRs we highlight the difficulty in integrating and consolidating data among different provides, considering that people uses different clinics, hospitals and laboratories [2]. Another issue is that besides storing patient's data, each EHR creates its

1 http://seriesestatisticas.ibge.gov.br/series.aspx?vcodigo=MS33
2 http://www.cetic.br/saude/2013/

own mechanism of security, requiring a specific set of credentials, such as user and password, locally managed by patients [5]. In a nutshell, the focus of traditional EHR generally is not the patient, but rather the relation between patients and the specific health provider.

In order to contribute minimizing this problem, this article presents the general ideas behind uHospital, a model to manage healthcare in hospitals. The main focus of the project is to propose a Personal Health Record (PHR) allowing patient's to control their medical history and symptoms, storing many information related to their personal health [2]. This PHR should include exams, diagnoses and any other health information possible related.

One possibility in this area, from the popularization of mobile devices and the growth of body sensors use (wearable computing), is to allow people to interact with their PHR, using tablets and smartphones, combining the stored information in their health record with vital signs that have been constant monitored. To allow this combination, uHospital proposes the use of situation awareness [1] to combine the patient's context, including data being constantly monitored, with information already available in their electronic health record. To fulfill this goal, uHospital employs ontologies based on international and established healthcare standards, including OpenEHR [3] and HL7 [4].

The article is further organized in three sections. Section 2 describes some background concepts. A general view of the model is shown in section 3. Finally, section 4 wraps up the article presenting some conclusions and directions for future work.

2. Background

Personal Health Record (PHR) allows individual control of all medical related information [2]. Some studies have shown that allowing people to manage and control their medical data, fosters the patient's cooperation with treatments and makes them more involved in the process [19]. Furthermore, the patient's role in the interaction with their PHR is bond to radically change with the widespread used of mobile devices. Not only they could be used as the means for accessing the information, but rather they can be integrated with sensors, allowing the gathering of health indicators, such as vital signs. The use of wearable and mobile devices allows real-time monitoring of people permitting the correlation of different data and a more proactive action [3]. Consequently, the PHR will be the combination of patient's health record, obtained from interaction with health providers, with data gathered from sensors or wearable devices, using user's smartphone [13] [12].

3 http://www.openehr.org

4 http://www.hl7.org

This scenario directs to the concept of ubiquitous health, consisting of using mobile and ubiquitous computing [6] concepts to monitor patients' health anywhere and anytime, without the need of having them physically presented in clinics and hospitals. The idea of maintaining pervasive medical care, has been called ubiquitous healthcare, consisting in providing a convenient service to patients, easing the diagnostic of clinical conditions, improving efficiency, accuracy, and availability of medical treatment [10].

The convergence of ubiquitous healthcare with PHR come into sight from three factors: the natural evolution of information access from mobile devices, the inherent mobility of those devices, and the integration of assorted sensors [12]. This convergence may bring ethical challenges, such as data privacy, and several research opportunities, given the physical limitations of mobile devices (in terms of memory, energy and power processing), compatibility between different platforms, and handling the large amount of data that could be gathered from sensors [3] [12].

3. uHospital Model

The uHospital model explore the concepts of ubiquitous health and ubiquitous healthcare in hospitals. The proposal consists in defining a model for managing health in hospitals using many concepts related to mobile and ubiquitous computing. Among the employed concepts, we highlight the use of information related to the users, such as their vital signs. This idea, named context awareness, consists in using available information regarding people and their surrounding [7] [8]. Particularly, the proposal focus on the use of a special kind of context awareness named situation awareness, in which many types of context are aggregated to generate a more complex view of the circumstance [18]. The idea of using situation awareness is to interact with users, learn their behavior, using information obtained from physical and virtual sensors, and making autonomic actions according to the circumstance detected [1].

The model central focus is on electronic health record, which is identified as one of the main challenges to be addressed by the emergent ubiquitous technologies to the health area [15] [17]. More specifically, the model proposes a PHR accessible from mobile devices, using the situation awareness in order to detect possible risks to patient's health. Using this information, health providers can act in a proactive way. Some additional characteristics have been used in the proposal to address some other current limitations in PHR proposals. To foster interoperability with others PHRs and EHRs, the solution is based on a set of international standards, including the already mentioned OpenEHR and HL7. Particularly, we are employing the HL7 Clinical Docu-

ment Architecture (CDA)[5], the set of characteristics defined by the Joint Electronic Personal Health Record Task Force [11], the ISO/TR 20514:2005[6], which defines informations that should be present in EHRs and also the more recent ISO/TR 14292:2012[7], which specifically covers Personal Health Records. In the model, PHR informations are stored in an ontology allowing the use of inferences to detect possible situations and defining involved risks [14] [19].

In terms of architecture, the model uses the concept of mobile cloud computing, in which part of the data and processing is done out of the mobile device, allowing to surpass the physical limitations of those equipments [9]. To deal with privacy and security, further improving the interoperability with different providers, the model uses OpenID, an international standard to create identities and distributing credentials employed by many Internet providers [5] [4].

In this way, the present model aims at answering the following research question: *How is it possible to improve the efficiency of health management in hospitals, by storing informations in a Personal Health Record, using the concepts of ubiquitous health and ubiquitous healthcare?*

4. Conclusion

This article presented uHospital, a model allowing the management of ubiquitous healthcare in hospitals, centered in a PHR, which permits the inference of patients risk. In the context of uHospital, the group of researchers at Unisinos is currently advising many dissertations and thesis. Although recent, the project fosters the relation with Sistema de Saúde Mãe de Deus, a group of hospitals located in the Rio Grande do Sul state and also plans to contribute to minimizing the efficiency of Brazilian Health area.

As a future work, we are in the process of developing a prototype of a PHR service based on cloud computing, and also clients for acessing it from iOS and Android smartphones. Furthermore, we are currently experimenting with the use of mobile and wearable sensors and investigating ways of detecting risks to patient's health regarding different pathologies, including heart fail, mental health and chronicler diseases.

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5 http://goo.gl/KjSqkq
6 http://goo.gl/F069V0
7 http://goo.gl/XZk5K5

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