Towards Context-Aware EHR-Based Healthcare Systems

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***Abstract*—In the medical world of today, healthcare professionals need to access the Electronic Health Record (EHR) of a patient not only on their desktop computer but also on mobile devices such as smart phones or tablets. Through the use of mobile electronic devices in everyday medical activities, the shortcomings of paper-based medical documents are limited removing the need of transcription or loss of documents and improving access to and search of patient's medical data. Mobility means awareness of a dynamic context whose richness can be used for infering new information and we believe that context-aware software approach is suitable for the medical world as healthcare professionals mobility is increasing. The proposed approach uses contextual information on the users of software applications involved in healthcare activities, patients and healthcare professionals to provide them with personalized, user-tailored views on the patients' EHR according to the scenario for which the application has been accessed. We have designed a system capable of perceiving context and reacting to ambiental changes to provide healthcare professionals and patients with EHR data dynamically generated according to the gathered information from the context. The user receives a customized view on the patient's EHR tailored upon her/his current context.**

Keywords-context aware computing; pervasive healthcare; mobile computing

I. INTRODUCTION

In the last years, attempts to implement national or regional healthcare systems supported by information systems that intensively use electronic devices have encountered many barriers: cultural, social and financial [1]. A major shift in healthcare will take place when care providers will realize that the critical element in work is the ability to exchange ideas, information and knowledge in a collaborative environment and that improved information *communication* benefits *caregivers and their patients*. From a social point of view, the main concerns are the privacy and the security of the stored data; it is well-known that a computer system is not 100% protected from data leaks or hackers' attacks. Regarding the financial issues, most of the professionals involved in the healthcare domain consider that investing in a system that would provide assistance in healing patients is not a must-have. This argument arises especially in countries or regions where capital resources are limited [1].

In the last years, the concept of mobility gained new dimensions by the multitude of devices emerging on market: personal device assistants (PDAs), smart-phones, tablet-PCs and notebooks. Nowadays, these devices are light, powerful and accessible and they provide mobility, ubiquitous access to information and enable easy interconnection of their users [9]. The growing market of mobile devices has encouraged the development of applications in medical fields. Several hospital-based prototypes have been proposed: "WardInHand" [6], "MobileWARD - Mobile Electronic Patient Record" [5], "Intelligent Hospital Software" or "Context-aware mobile communication". Each of these programs ended with questionnaires filled up by medical staff that interacted with it and the feedback is generally positive. Except "WardInHand", these prototypes make use of the idea of context-aware computing, a term first introduced by Schilit and Theimer and defined as "the ability of a mobile user's applications to discover and react to changes in the environment they are situated in" [8].

Studies [1, 7, 9] have shown that in last few years healthcare professionals have started using mobile devices as assistants in their daily work. However, ubiquitous access to EHR database does not improve the medical workflow. The guiding idea of this paper is that on the one hand, not all the information from a patient's EHR is needed at some point but only those relevant to the current situation, sometimes browsing a large amount of medical data and selecting the useful one may prove difficult and time-consuming. On the other hand context information can be used to better customize the presentation of the EHR's selected information to the final user. We explore the idea of endowment of an EHR system with the ability to perceive the contextual information of its users and to use it to sort out EHR data and consequently provide the users with it. We propose a system to react dynamically to situations for which it is accessed and provide its users with a customized view of the patient's EHR. A customized selection of EHR's data built upon contextual information will provide users with increased access and shorten the time needed to browse and search clinical data, increasing the efficiency of the medical staff. We also explore the idea of adapting EHR

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data to user's preferences and profile (e.g., font size, font color or background picture).

The paper is structured as follows: Section II depicts the contribution of the context-awareness paradigm in improving EHRs security and afterwards focuses on contextual attributes of healthcare domain's actors and emphasizes their particularities. Section III describes the overall structure of our model. In particular, we propose an architecture, make a thoroughly description of our approach and discuss its utility from a patient point of view. Section IV concludes the paper.

II. CONTEXT DATA IN HEALTHCARE ENVIRONMENTS

This section begins with a discussion regarding EHR systems security issues and improvements that may be brought by considering users' context. Afterwards, we outline how context-aware computing paradigm may add value to a conventional EHR system, and finally, we review various definitions of context-aware computing and present the contextual attributes of the actors involved in the healthcare process, healthcare professionals and patients, emphasizing their particularities.

A. Security and privacy

In the last few years, some of the reasons of reluctance in implementing EHR systems were the security and the privacy concerns regarding the data stored [11]. As many EHR systems are centralized (region- or country-wide) unauthorized access can have negative effects; once you are logged in to the system one can access and even modify private data of the patients causing possible permanent loss of data. Besides the integrity concerns, all the reads must be thoroughly authorized as the healthcare data distinguishes by its sensitivity. However, significant improvements were made towards security. For example, in the United States, Health Insurance Portability and Accountability Act (HIPAA) stipulates that patients can request a detailed list of all the accesses through their medical records [1]. One way to implement this facility is a user-centric auditing system, i.e., a portal where the user logs and sees a history of individuals who accessed their personal data.

Moreover, each patient having a network-accessible EHR can indicate which are the public information from her/his own record and which are private, each country implementing regional or countrywide EHR systems has imposed regulations regarding security and privacy of electronic stored data and backup systems have been proposed such that intentional or unintentional loss of data to be prevented.

As regarding security of EHR systems, studies have been made regarding healthcare domain actors' contextual attributes particularities and their influence in improving EHR's access control and security. Shetty and Loke proposed a dynamic context-aware access control model [12] and they suggested using subject, time and activity while replacing location with resource as location cannot stand on its own without resource or subject.

B. Mobility and context-awareness

Paper-based health records have shortcomings for both patients and healthcare providers, e.g., usually the health record of a patient is a single hard-copy kept by one medical institution rendering outside access to it difficult and cumbersome; manually search of data may be time-consuming; volatility of paper brings risks like partial loss of data or even irretrievable loss of data. Paper-based health records provide to healthcare providers an amount of data difficult to access, search or summarize and to the owner a risk of losing it.

Through the implementation of centralized EHR systems the mobility of medical documents has increased requiring to each healthcare institution only an Internet connection to be able to access the remote EHR. Studies [9, 11] have reported that implementation of EHR systems tend to reduce or even eliminate shortcomings of paper-based health records by increased security, ubiquitous access, reduced costs and the ability to predict and reduce the effect(s) of medical conditions. Implementation of different healthcare systems (e.g., WardInHand [6], MobileWard [5] or Clinical Trials Information System [7]) brought to the forefront of healthcare providers the mobiles devices, e.g., PDAs, tablets or smart phones moving the task of accessing, updating and changing medical data from desktop computers to mobile devices. This transition brought mobility to healthcare providers enabling access to EHR virtually anywhere, anytime being no longer constrained to use a desktop computer.

Powered with mobility enabled by mobile devices and the context-aware paradigm, the EHR systems may be seen from a new perspective, by adapting itself to the user's context in one specific situation, thus facilitating easy, quick and comprehensible access to situation-tailored EHR data. The transition of medical documents from desktop computers access to mobile devices involves moving from a relative static context to a dynamic one where not only the healthcare provider specialization involved is important but also the actors' location and the patients' circumstances, e.g., a routine or emergency situation or the device used for accessing data.

C. Particularities of contextual attributes in the healthcare domain

Interaction between the healthcare providers and an individual begins when the health state of the latter significantly worsens with respect to its regular state. From this point a team of healthcare providers (e.g., physicians, surgeons, nurses or radiologists) work together to cure the patient and to bring his health state to a normal level. During a medical treatment the team members provide each other with data according to their medical specialization and collaborate for improving the medical condition of the

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individual. Each member of the team has a specific role and given tasks which must be accomplished in a given period of time. The interaction with patients needs to be supported by accurate and detailed information regarding patients' past medical condition so the clinical history of the individuals should be structured and accessible in a meaningful way.

In [15], a context service is designed enabling the collection of contextual information which is further forwarded to interested clients. Henricksen, et al. [16] suggests that in pervasive computing applications the most relevant context information consist of the capabilities of the mobile devices, the characteristics of the network, user specific information and user preferences. Schilit, et al. [8] observed that contextual information goes beyond user's location because other things of interest are changing. Bettini, et al. describes a situation as being "a temporal state within context" [17].

Two of the most used context-aware computing definitions, that of Schilit, et al. [8] and that of Dey [18] place the space above other context categories. Individuals tend to associate a particular location with specific situations which they analyze and infer additional information upon [17]. The interaction of a healthcare provider with the EHR system begins when he logs in, at this point the system should gather the user's attributes (e.g., name, position inside medical institution or medical specialization), graphical interface preferences (e.g., font size or font type), location (e.g., inside hospital, inside ambulance or inside extrication car), the capabilities of her/his mobile device accessing the system (e.g., touch screen one, full keyboard one or size of the screen), etc. During a session, while some context information remain unchanged (e.g., user specific information or the capabilities of the mobile device accessing the system) others may evolve (e.g., user location or user preferences for information presentation).

Gathering patient-side context information is not a simple task to do as these data may be subject of uncertainty or/and inaccuracy of the source (e.g., human or devices). In certain circumstances like calling an ambulance or extrication service a second person reports about individual(s) requiring medical assistance. As in most cases the caller has little or no medical knowledge she/he may report vague information (e.g., the caller reports that an individual is bleeding but does not know the source of bleeding) or inaccurate data (e.g., an individual may have fainted but in fact he suffered a heart attack). Dey's definition of the context concept "any information that can be used to characterize the situation of an entity" [18] suggests that any information regarding the individual's needing medical assistance may be helpful to the system; of course, interpretation of possibly inaccurate data should be approached carefully. On the other hand, when the patient is hosted inside a healthcare organization medical observations are made by healthcare professionals, medical equipment is used for monitoring and all these data can be considered reliable, that is they accurately reflect the patient's health condition.

Our approach considers the context information emerging from a dynamic context analysis and uses it to compose a view on the patient's EHR that delivers to its users data tailored according to their current context, thus improving access and browsing of medical data.

III. CONTEXT-AWARE ELECTRONIC HEALTH RECORD

This section starts by presenting two scenarios and is followed by the description of our approach to an intelligent EHR system. We present how the system is able to react to the context inferred from the gathered contextual data of both the healthcare provider and patient and how it selects relevant data from patient's EHR and displays it according to the user's preferences. An architecture for the Context-Aware System is presented in Fig. 1. Throughout this section, short paragraphs expose current issues and based on these, we motivate choices to our approach. We conclude this section with a discussion on patients' benefit from using the system.

A. Scenarios

This section present two common medical scenarios and the main concerns of the roles playing these scenarios are identified. We then discuss how the Context-Aware EHR system can provide medical data to healthcare professionals and patients according to situation, place, time and available resources of both doctor(s) and patient(s).

Scenario 1

A paramedic working at SMURD Bucharest, an emergency rescue service established in Romania, during his shift is informed that he must take part in an extrication mission. On his way to the accident site he has 7 minutes to examine the EHR(s) of the victim(s) involved in the car accident and to gather personal information like age, previous diseases and chronic conditions of victim(s).

After providing first aid and after patient(s) stabilization the paramedic takes them to the hospital. Meanwhile, (s)he fulfills a mission report and enters it to the system providing all the details about the victim(s) and their health status to doctors from the emergency room.

Note: The 7 minutes interval is the average time of intervention of a SMURD ambulance in Bucharest [13].

Scenario 2

Andrew, a 16 years-old athlete is hospitalized for 2 days in Orthopedic Unit of the Hospital of St. John and St. Elizabeth from London. From the first medical tests doctors diagnosed the young boy with Osgood-Schlatter disease and before prescribing medications and sending him to a physical therapist doctors want to perform additional tests as his disease has relapsed. Meanwhile, during his stay in hospital, Andrew wants to know more on his disease and on possible causes of relapse.

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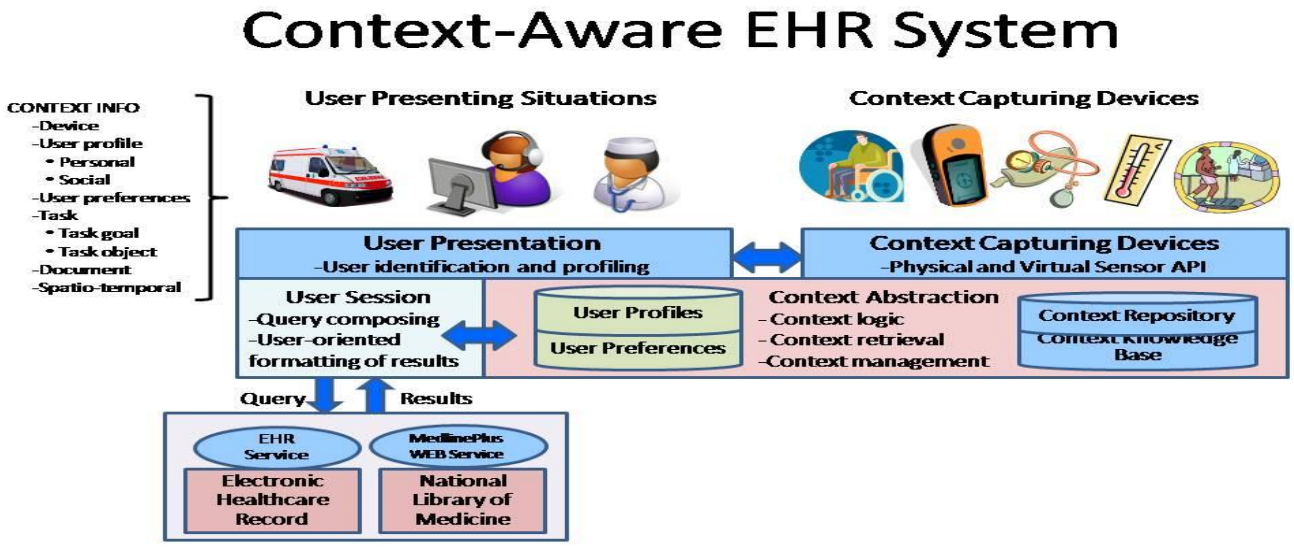

Figure 1: The architecture for the Context-Aware EHR System

In the first scenario, the time-critical situation requires an efficient management of both information and resources. On his way to the accident site the paramedic should be informed on the accident (e.g., number of victims, their health status, accident severity, weather conditions) and on the victim(s) (e.g., age, last known health status and previous diseases). When the paramedic accesses the EHR system (s)he should be provided with data according to both her/his and victim(s) context so that only the information needed for providing first aid (for example: age, last known health status, previous diseases) to be displayed upon his preferences which may include for example font type, font size, with/without images.

In the second scenario, while trying to inform about his disease, Andrew accesses his EHR and browses his past personal medical information. As his EHR stores a large amount of data, finding the desired information may prove laborious and also several medical terms specific to healthcare professionals may prove difficult to be understood. On one hand he needs to find out information on past symptoms and medical tests and on the other hand he needs to find out information on followed medical treatment and physical recovery.

When accessing the EHR, one way of making the EHR data comprehensible and easy to browse by the user is to perceive the user's context. For instance using Hyun-Yong Noh, et al. [19] indoor localization technique Andrew's location inside hospital can be determined with a high level of accuracy (Orthopedic Unit). Location along with information on device used for accessing the EHR (e.g., tablet PC or smartphone), the user's profile and preferences (e.g., font size or background picture) are used by the system for sorting out information and displaying it according to user's concerns. Moreover, for a non-professional, i.e., the user belongs to the patient profile, the system may provide more comprehensible synonyms of medical terms and web-site links related to current disease to provide information on treatments or physical recovery.

B. Context discovering

In order to react according to current needs, the system has to gather specific data about the current situation as well as data related to the main stakeholders: patients and healthcare professionals. As a registered user logs on to the system his profile and personal preferences are retrieved from the user database and used by the system to customize the user interface. This is particularly important as the user should feel comfortable with the way the data are displayed. According to her/his stored preferences, text will be formatted with the desired font size, font type and font color and the images will be properly sized.

As the user may access the system from a multitude of devices (e.g., desktop computer, tablet, smartphone or notebook) the next step is to gather the device capabilities (e.g., screen size, input mode or network connection speed). Sensing the device capabilities along with the available bandwidth avoids locking the connection until the transfer of a high resolution image (such as radiography) in which case it may be suitable to send a lower resolution image to the requesting device. Device's contextual information help improve the visual appearance of data displayed by smart scaling the images and the text to fit the screen size [14].

Once the user is authenticated, a session instance is created for her/him. As individuals have the right to expect their EHR data are kept confidential and they are the only to decide which medical information is public and which is private, our system comply with these regulations through inheritance of security, privacy and confidentiality levels regarding EHR data, owned by the EHR system. On each session instance an encrypted communication channel with

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the EHR database is established ensuring that the data cannot be intercepted by unauthorized persons.

During the user's session, the Context Service that runs in background continuously gathers contextual information from the context-associated sensors (e.g., GPS sensor, temperature sensor or light level sensor) and updates to the content of a Context Repository with it, in this way consistent and up-to-date contextual data is provided to the system.

Sensors can be both physical and "virtual". The physical sensors gather information such as:

- Environmental, e.g., temperature sensor or light level sensor;
- Location, e.g., by means of a GPS sensor;
- Medical data, e.g., heart rate or blood pressure.

"Virtual" sensors gather context data from software applications or from operating system. Regarding our approach, the "virtual" sensors may supplement certain unavailable sensors or communicate with third-party institutions (e.g., emergency call centers or police). For example, as the position inside a building cannot be determined using the GPS sensor, a "virtual" sensor invokes a localization service which determines the position of the user using indoor localization techniques proposed by Hyun-Yong Noh, et al. [19]. As emergency call centers have implemented an automatic detection system of the caller's context (e.g., GSM cell-based location, name or age) it is suitable to have a background application which automatically gathers these patient contextual data removing the need of manually forwarding these data to emergency medical institution.

However, sensors capabilities are limited. As there are situations in which the sensors cannot gather a particular contextual information we think it is important to endow the Context-Aware EHR System with the ability to manually input authoritative contextual data and thus enable explicit user actions (e.g., manual entry of the patient's symptoms) [20].

In the context discovery phase, the Context Service gathers all the available contextual information and stores them in the Context Repository and it is further updated as information changes.

The stored Context Repository data provide to the "Inference Engine" contextual information to be used in the inference phase which will further provide the user with a personalized view on the EHR's data and a quick and comprehensible access to medical data relevant for the concrete, particular state of affairs. Table 1 summarizes the contextual categories proposed for our system and offers a detailed view upon contextual attributes of each category.

C. *Making context information useful*

Field studies reported that the topic of searching information within EHRs is insufficiently explored and the lack of the search functionality often hampers healthcare professional's access to patient's data [21, 22]. However, as the patient's EHR comprises large amount of data, a keyword search utility [22] does not ease access to information nor facilitates browsing. During clinical workflows contextual attributes and patient's health state change and we envision that a system which proactively gathers these parameters will be capable of continuously provide situation tailored data.

The aim of a doctor is to heal the patient or at least to soothe his pain in case of an incurable disease. Doctor's medical knowledge is somehow insufficient as making a proper diagnostic relies not only on knowledge or aptness to predict patient's health state evolution but on patient's clinical history. Setting a proper diagnostic is one of the critical points of the workflow as it backs the patient's healing process. The clinical history offers a better understanding of how the patient's health state evolved up to the current one and how past medical conditions influenced the current health state.

The "Inference Engine" endows the Context-Aware EHR System with the ability of acting proactively. It accesses the Context Repository and based on the acquired contextual information it queries the EHR database and extracts situation relevant information. The search through EHR considers three of its major sections:

- Text-based information, e.g., name, age, medical history or allergies;
- The collection of clinical images, e.g., radiographs or photos;
- The collection of videos, e.g., oral examination videos made with an endo-oral camera or colon videos.

One of the challenges of the system is to extract and provide the user with medical data according to a given context and to filter irrelevant information. This is done by the "Inference Engine". Namely, it follows the idea of ranking text-based information according to its relevance in a given context. Using patterns, the raw contextual information is associated with a collection of related terms which are further searched within EHR database. As for example if the patient has a dislocated right ankle the system will search his medical history to search for medical data related to his

TABLE 1. SUMMARY OF CONSIDERED CONTEXTUAL ATTRIBUTES

Context category	**Attributes**	**Source**
Personal profile	Name, age, specialization...	Users' repository
Preferences	Font type, font size, font color...	Users' repository
Device capabilities	Screen size, input mode...	"Virtual" sensors
Environmental	Date, time, temperature, light level...	"Virtual" or physical sensors
Location	GPS coordinates, place inside building	"Virtual" or physical sensors
Medical data	Heart rate, blood pressure...	Physical sensors

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right ankle. All the EHR data related to the patient's right ankle (e.g., diagnosis, medication prescribed or clinical decisions) will be high ranked as opposed to those which refer to his left ankle. A "Decision Frame" [23] is included to present the patient's relevant information. For the clinical images and videos the search is made through attached tags. Finally, gathered medical data are displayed according to the stored user's preferences and profile. In Section 4, we describe how specific medical terms and codes can be converted to general ones thus helping patients to understand their own medical data.

Additionally, a "Context Knowledge Base" is maintained and updated with information from the applications of healthcare professionals. It provides a collection of context-patterns extracted from previous contexts (e.g., the victim has suffered a frontal car accident so it may have caught his feet in the car body or the victim has suffered a heart attack and he may faint). Namely, each medical event and its contextual attributes is stored and in case of further events that match to a great extent it is shown. Previous medical situations and healthcare professionals' reports may offer a better insight of the actual situation as similar circumstances are probably to have similar effects. Each pattern is associated to the possible effects it may produce. Matching the current context with context-patterns in the knowledge base contextual information gain meaning and can be better used by the system to provide users with different point of views derived from previous similar cases. This inferred information will provide useful data for the current situation based on previous circumstances, thus predictions on patient's health state evolution can be made.

As noted above, the sensors, be they physical or "virtual" cannot gather certain information. Therefore, the context information may be vague and thus the system may retrieve insufficient EHR data. The Context-Aware EHR System does not restrict the user to one particular, scenario specific, patient's data view, if more EHR data are needed the system can be further interrogated by standard queries requesting the missing pieces of information. The retrieved data are further merged with the inferred one.

D. The Context-Aware EHR System. A patient point of view

The EHR is a collection of medical information which reflects patients' past medical history. It comprises highly structured data and its entries use standard codes and classifications for representing medical data. This standardization may seem fair for healthcare professionals since the EHR systems promote collaborative and goal-directed treatment planning [27, 26] but may appear cumbersome as patients don't usually have medical knowledge and thus they may encounter problems in accessing and understanding their own medical records. Recent works [25, 28] have explored the concept of "active patient" which no longer sits on the sideline waiting for the doctor to cure her/him but actively participate in his own care. Of course, to increase the efficiency of the "active patient" he must be endowed with tools.

MedlinePlus Connect is a health information resource freely provided by National Library of Medicine (NLM), National Institutes of Health (NIH), and the Department of Health and Human Services (HHS) aiming both patients and healthcare providers. It handles medical standard codes and retrieves related information (e.g., for a medication code the side-effects, dosage or special precautions for that medicine).

In order to obtain a patient-friendly EHR data view we make use of the above mentioned MedlinePlus Connect Web Service; a standard encoded message is converted to a non-professional user-friendly format and, consequently, lab tests, medications and diagnostic codes and other specific medical information gain meaning for the general public. Additionally, through "Context Knowledge Base" more context-specific information will be available for each context-pattern, i.e., patients can review similar previous medical situations thus be aware of the evolution of their disease and possible complications.

"Sensing user" role empowers patients to participate more in their healthcare workflow process and to be aware of what has been done and what is further planned in their care process.

IV. IMPLEMENTATION ISSUES AND PROTOTYPES

As the proposed system needs to proactively act according to a medical situation we first need a services platform to support context-aware application. In our future implementation we plan to use WASP platform [29], a robust and configurable services platform which gathers and provide contextual information to subscribed clients. We are aware that unavailability of certain contextual information may lead to incomplete data shown to users so we will implement and test the facility to refine the results through manually specifying certain contextual attributes and through standard queries.

One important issue regarding EHR systems is the unavailability of medical data due to its absence from the medical records or due to owner's desire to keep it private. We will develop several test scenarios and together with patients and healthcare providers we will try to enhance the quality of retrieved results. The patients are those to set their own EHR level of confidence and with respect to the proposed scenarios to have healthcare providers' opinion upon retrieved medical data degree of detail. This particular research is important on one side for patients as they can see the impact of different levels of confidentiality upon retrieved medical data and on the other side for healthcare professionals as unavailability of certain data leads to incorrect diagnostics or hinder him to have patient's clinical picture.

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V. CONCLUSION AND FUTURE WORK

As sometimes search of information in large databases may be difficult, structuring EHR's information according to situations' specific needs enables a predictive medical information retrieval. Of the patient the system brings the opportunity of accessing the EHR medical information without the need of knowing the messaging standards (e.g., HL7 v3 or HL7 v2.x). The system uses the perceived contextual information and determines which medical data match the given circumstances and may be of interest.

The leading idea of this paper is to build a system to help EHR users retrieve medical data other than using standard ways which in certain cases proves to be cumbersome and time-consuming. To our knowledge, this study was the first to embed the conventional EHR database into a system which gathers user's contextual information and uses it to proactively retrieve patient's medical data tailored on user's device capabilities. Through a customized view of the EHR data, healthcare providers have they work supported by easy and comprehensible data access and also, patients are offered an interpretation of their medical data for a better insight. However, it is important to note that users are not restricted to this particular, scenario specific, patient's data view. If the Context-Aware EHR System retrieves exiguous information the user can query the EHR database typically in order to obtain the missing pieces of information.

We are currently planning a pilot deployment of our proposed approach followed by in-depth interviews and surveys with its users on application's usefulness. We also plan to build a complementary system to support entering to the EHR medical data along with of contextual information.

REFERENCES

[1] D. Gans, J. Kralewski, T. Hammons and B. Dowd, „Medical Groups' Adoption Of Electronic Health Records and Information Systems," Health Affairs, 24, no.5 (2005):1323-1333, doi: 10.1377/hlthaff.24.5.1323.

[2] http://ehealth-strategies.eu/database/documents/Estonia_CountryBrief_eHStrategies.pdf. Retrieved: February, 2012.

[3] http://www.sante.gouv.fr/acces-web-patient.html. Retrieved: February, 2012.

[4] http://ehealth-strategies.eu/database/documents/France_CountryBrief_eHStrategies.pdf. Retrieved: February, 2012.

[5] M. B. Skov and R. T. Høegh, "Supporting Information Access in a Hospital Ward by a Context-Aware Mobile Electronic Patient Record," in Crestani, F. et al. (Eds.) Personal and Ubiquitous Computing, 2006, Vol. 10, No. 4, pp. 205-214.

[6] M. Ancona, E. Coscia, G. Dodero, M. Earney, V. Gianuzzi, F. Minuto, and S. Virtuoso, „WardInHand: Wireless Access to Clinical Records for Mobile Healthcare Professionals," Proceedings of 1st Annual Conference on Mobile & Wireless Healthcare Applications, London, United Kingdom, 2001.

[7] M. A. Grasso, "Clinical Applications of Handheld Computers," Proceedings of the 17th IEEE Symposium on Computer-Based Medical Systems (CBMS '04), IEEE Computer Society, Washington, DC, USA, 2004, pp. 141-. DOI:10.1109/CBMS.2004.28.

[8] B. Schilit, N. Adams, and R. Want, "Context-Aware Computing Applications," Proceedings of the 1994 First Workshop on Mobile Computing Systems and Applications (WMCSA '94), IEEE Computer Society, Washington, DC, USA, pp. 85-90, DOI:10.1109/WMCSA.1994.16.

[9] N. Bricon-Souf and C. R. Newman, "Context Awareness in Health Care: a Review," International Journal of Medical Informatics 76(1), pp. 2–12 (2007).

[10] L. Barkhuus and A. K. Dey, "Is Context-Aware Computing Taking Control away from the User? Three Levels of Interactivity Examined," Proc. Ubicomp '03, Springer (2003), pp. 149-156.

[11] N. Menachemi, T. H. Collum, „Benefits and drawbacks of electronic health record systems," Risk Management and Healthcare Policy Journal, vol. IV, pp. 47-55 (2011).

[12] P. Shetty and S. W. Loke, "Modelling Context-Aware Security for Electronic Health Records," Encyclopedia of Information Ethics and Security (ed) M. Quigley, 2007, pp. 463-469, IGI Global.

[13] http://www.paginamedicala.ro/stiri-medicale/SMURD-Bucuresti-implineste-doi-ani_7437/. Retrieved March, 2011.

[14] D. Zhang, Z. Yu, and C. Chung-Yau, "Context-Aware Infrastructure for Personalized Healthcare," The International Workshop on Personalized Health (pHealth 2004), IOS Press, pp. 154-163, December 13-15, 2004, Belfast, Northern Ireland, United Kingdom.

[15] H. Lei, D. M. Sow, J. S. Davis, G. Banavar, and M. R. Ebling, "The design and applications of a context service," SIGMOBILE Mob. Comput. Commun. Rev. 6, 4 (October 2002), pp. 45-55, DOI:10.1145/643550.643554.

[16] K. Henricksen, J. Indulska, and A. Rakotonirainy, "Modeling Context Information in Pervasive Computing Systems.", Proceedings of the First International Conference on Pervasive Computing (Pervasive '02), Friedemann Mattern and Mahmoud Naghshineh (Eds.), Springer-Verlag, London, UK, pp. 167-180.

[17] C. Bettini, O. Brdiczka, K. Henricksen, J. Indulska, D. Nicklas, A. Ranganathan, and Daniele Riboni, "A survey of context modelling and reasoning techniques," Pervasive Mob. Comput. 6, 2 (April 2010), pp. 161-180, DOI:10.1016/j.pmcj.2009.06.002.

[18] A. K. Dey, "Understanding and Using Context," Personal Ubiquitous Comput. 5, 1 (January 2001), pp. 4-7, DOI:10.1007/s007790170019.

[19] N. Hyun-Yong, L. Jin-Hyung, Sae-Won Oh, H. Keum-Sung, and Sung-Bae Cho, "Exploiting indoor location and mobile information for context-awareness service," Inf. Process. Manage. 48, 1 (January 2012), pp. 1-12, DOI:10.1016/j.ipm.2011.02.005.

[20] P. Coppola, V. Della Mea, L. Di Gaspero, S. Mizzaro, I. Scagnetto, A. Selva, L. Vassena, and P. Z. Rizio, „MoBe: Context-aware mobile applications on mobile devices for mobile users," Proc. of 1st int. workshop on exploiting context histories in smart environments (ECHISE 2005).

[21] T. Christensen, A. Grimsmo, "Instant availability of patient records, but diminished availability of patient information: a multi-method study of GP's use of electronic patient records," BMC medical informatics and decision making, Vol. 8 (28 March 2008), 12, doi:10.1186/1472-6947-8-12.

[22] K. Natarajan, D. Stein, S. Jain, and N. Elhadad, "An Analysis of Clinical Queries in an Electronic Health Record Search Utility," International Journal of Medical Informatics - July 2010, Vol. 79, Issue 7, pp. 515-522, DOI: 10.1016/j.ijmedinf.2010.03.004.

[23] E. Bayegan, Ø. Nytrø and A. Grimsmo, "Ranking of Information in the Computerized Problem-Oriented Patient Record," Medinfo 10 (Pt 1) (2001), pp. 594–598.

 ISBN: 978-1-61208-215-8

[24] K. Sadegh-Zadeh, „Fundamentals of clinical methodlogy 4. Diagnosis," Artificial Intelligence in Medicine, Vol. 20, Issue 3, pp. 227-241, November 2000.

[25] D. Vawdrey, L. Wilcox, S. Collins, S. Bakken, S. Feiner, A. Boyer, and S. Restaino, „A tablet computer application for patients to participate in their hospital care," Proc AMIA 2011, pp. 1428-1435.

[26] K. J. Leonard and W. J. Winkelman, „Overcoming Structural Constraints to Patient Utilization of Electronic Medical Records: A Critical Review and Proposal for an Evaluation Framework," Journal of the American Medical Informatics Association, 2004, March-April, 11(2), pp. 151-161.

[27] H. Stam van Ginneken, "Computer-based patient record with a cardiologic extension", Medinfo 1995, 8(Pt 2):1666.

[28] L. P. Vardoulakis, A. Karlson, D. Morris, G. Smith, J. Gatewood, and D. Tan, "Using mobile phones to present medical information to hospital patients." In Proceedings of the 2012 ACM annual conference on Human Factors in Computing Systems(CHI '12). ACM, New York, NY, USA, 2012, pp. 1411-1420, DOI=10.1145/2207676.2208601, http://doi.acm.org/10.1145/2207676.2208601.

[29] http://www.freeband.nl/kennisimpuls/projecten/wasp/. Retrieved: March 2012.

 ISBN: 978-1-61208-215-8