Medical Carnet for Management of Patients Driven by Ontologies

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Abstract. Nowadays, management of patients in hospitals and clinics is automated by computer systems. Nevertheless, the patients no have a direct participation in this process. If patients would have a digital medic carnet, stored in his/her cell phone, other clinics and hospitals could explore this information, facilitating diagnosis and medical treatments. We propose a web and mobile system based on digital medic carnet stored into cell phone. The medic carnet will be available for doctors and patients using Bluetooth communication from a computer or cell phone. Ontology is designed to assist doctors in the diagnosis and treatment of diseases, and to assign a specialist according to ailment and previous diagnosis. The Medical carnet represents the clinic history of patient, it will be available for paramedics, and will be very useful in emergency cases, when is required to provide immediate medical attention. Then, ontology proposes treatments according to possible allergies and sufferings of the patient. The administration and management of the patient's medical history is done through a web application. Were tested Bluetooth communication among cell phones, cell phones-computer and computers-computers. The main contribution is the integration of semantic similarity in a mobile and web application oriented to doctors and patients.

Keywords: Mobile software, Ontology, Management patients, Bluetooth communication.

1 Introduction

Presently, Bluetooth technology has become the most popular media for sharing information between mobile devices, cell phones, computers and other software applications. In addition, the mobile software has been consolidated, including applications addressed not only to communicate to people, but also for entertainment, assistance, electronic commerce and to store personal information of user (even private and confidential). In this direction, the documents of common use, such as identification and medical carnets which contains medical history of user and affiliation to a hospital. The information contained in this document is available only

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when people visit doctor or hospital. Therefore, a mobile software for management a medical carnet, would be easier achieve tasks of diagnosis, treatment and monitoring in case of accidents, where information can be accessed even when the patient is unable to provide this information to paramedics, because serious psychological trauma that causes an accident.

In addition, software installed into cell phone that be the equivalent in use and usefulness of the paper medical carnet represents several benefits. In this sense, according to INEGI, 61% of the families in Mexico already have cell phones [1].
Moreover, considering ontologies development and semantic processing let to offer solutions, suggestions, and even assist into making decisions in the medical field and hospitals. From diagnosis to suggested treatments according to patient's medical history. The system presented uses the capabilities and technologies for mobile devices to create an electronic medical carnet that is stored on mobile devices, and can be accessed via Bluetooth, and Web by a paramedic, in case of an emergency. System offers suggestions of doctors who can treat a patient and other treatments that can be applied to a patient.

This is the main motivation of our work, the integration of wireless communications, mobile software, representations of knowledge such as ontologies, and the consolidation of the web to provide a solution for patients and doctors in clinics and hospitals in tasks of diagnosis and treatment.

2 Problem statement

Today, medics and paramedics face several problems, one of them is to provide adequate care when no information about the patient is available, in cases where a patient suffers an accident or he/she cannot provide this information. The protocol indicates that before treating the patient, the paramedic must make a series of questions to offer a diagnosis of patient condition and to know previous suffering or medical conditions that may require special treatment. But at least two cases are not considered: when patient does not know all his/her medical data, then it results that information can be wrong or incomplete, the second one occurs in accidents, where persons loses the ability to communicate, in this case, paramedics are forced to work on uncertainty, risking the life of person: any decision of paramedic could be counterproductive for the patient. Therefore, in these cases, a system would be useful, if this provides the information necessary to offer a safe and effective treatment to the patient; this is part of our proposal.

3 State of art

The development of mobile applications addressed to health care has started with other systems, such as “Primary care plus ambulatory and Hospital Care Suite (PCP)” [2] which is a suite that let to see medical information on Palm OS, Windows Mobile, or Internet. There is also the case “Emedic” is a medical encyclopedia. While in [3]

people who have a 3G mobile device may have their medical records (including x-rays, records of pressure, etc.) disadvantage is the cost of these devices and the cost of mobile application.

The communication system "Vocera" [4], developed in St.Vincent hospital, Birmingham, USA. It is a communicator badge system for mobile users with a push-to-call button, a small text screen and voice-dialing capabilities based on speech recognition. Moreover, the "Context-aware mobile communication" [5], developed in Mexico provide contextual messaging, for example, "a message for room 226 to any doctor, delivery time for the message today after 2 p.m.". while that "Intelligent hospital software" [6] provide remote query, tracking of patients and equipment, notification of awareness and patient data, an experimental prototype is implemented with function for starting an audio–video conference from the nearest point. Doctors are localized, are notified of the call. This prototype is presented as a demonstrator of the middleware platform QoS DREAM, for reconfigurable multimedia streaming and event-based programming. The first two applications only serve as reference for the diagnosis; the third has the patient information, however, the disadvantage that mobile devices should be 3G. In contrast our system can be used in any system that supports Java J2ME technology and JSR82 specification.

4 Methodology

Our methodology is a system composed of three applications: 1) A mobile application for patients and doctors 2) A web application to medical management in hospitals 3) an ontological module for assisting doctors in diagnosis tasks and treating diseases.

The former has the ability to store, send and receive medical cards via Bluetooth. Later, the medic carnets will be available by Web application. An ontology that stores concepts: patients, doctors, diseases, diagnosis and treatment received by patient. The system architecture consists of three modules, the module that resides in the hospital where administrators, paramedics and patients are registered. In addition, the ID card of paramedic and medical carnet of patient are transferred to their respective cellular phones. In addition, save reports generated on the paramedic cell phone, these are received by the hospital terminal via Bluetooth. The second one and third module are mobile applications that are installed in cell phones of paramedics and patients respectively. These are shown in Figure 1.

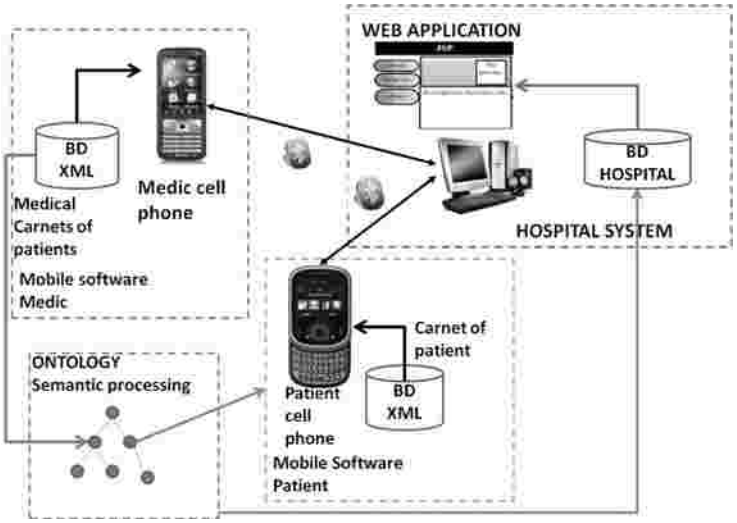

Fig. 1. Framework of system

As shown in Figure 1 we have three modules: the mobile module for patient and doctor, the web module and the module ontological. The web system module manages user information, classifying them as administrators, paramedics and patients. Registration of a paramedic or a patient is achieved by generating an XML ID card which is sent to cell phone of patient. When a modification on card occurs, then administrator can update the carnet stored into his/her cell phone. The process of sending and receiving data by Bluetooth is made through the mobile module. Paramedics make reports, starting session by sending ID card by Bluetooth, then patient files can be transferred, as well as medical records, events attended and care provided to patients.

The mobile module requires the establishment of Bluetooth communication search for services is performed in hidden mode for mobile phones and not in other devices to reduce the time of connection establishment. In this scenario to resolve the potential conflict posed by the existence of several cell phones that have the same application surround of paramedics, then, only the paramedic will activate the application manager on cell phone of patient, by sending a password. It provides confidentiality of the information and ensures that only will be obtained the patient's medical history data.

The ontology module processes semantically the information contained into mobile database and from web database. The ontology contains concepts related to patients and their ailments, and relationships among patients and doctors according to certain disease. The semantic processing of these concepts and relationships let offer two functions: 1) suggestions in the medical diagnostics (processing the semantic similarity of medical treatment), 2) suggest a doctor or specialist according to diagnosis that give the doctor (similarity in diagnosis). The ontology structure is show in Figure 2.

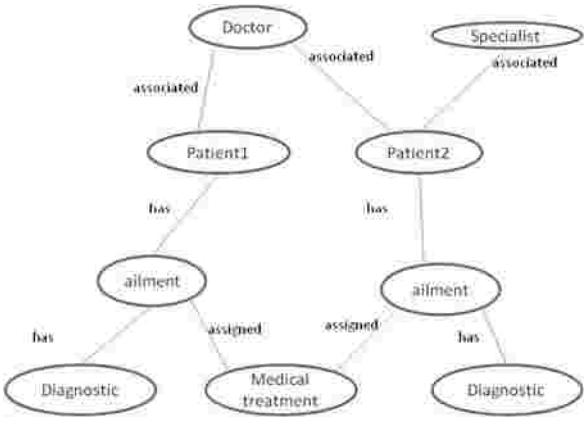

Fig. 2. Conceptual structure of Ontology.

The ontology was implemented in OWL and is explored using the SPARQL language, and as shown in Figure 2, have six concepts are: Patient, Doctor, Specialist, ailment, Medical diagnostic and treatment. Through the semantic relationships between concepts (has and assigned) you can find doctors and specialists who have examined a patient, what treatments have been applied, and sufferings undergone by the patient. Finding similarities among treatments, and offer suggestions in the medical diagnosis, and suggest a doctor or specialist according to medical historic.

Semantic processing is performed in two steps: 1) exploring the ontology to find the requested concept, 2) Extracting context and semantic relationships among concepts are processed.

To explain these steps, we consider the ontological module functions, where the first one is to determine the semantic similarity in medical treatments, for offering suggestions in diagnosis tasks.

For the first step, suppose we search: "ailment", ontology is explored from the parent node until you find the concept associated to "ailment". When this is found, second step is applied, which extracts the context of the concept searched, in this case is ailment (the context are the concepts associated by relationships "has" and "assigned"). Then, assigned relationship lets know what medical treatments have been applied to other patients. While the semantic relationship "has" lets to get other patients that have suffered the same disease. Then you can compare the treatments applied to other patients to find semantic similarities between them (e.g. the chemical substance of different medicaments used in treatments). Moreover, the system indicates when several patients have been reported with the same disease in a short time range (days or hours), indicating that it may be an epidemic.

Now, we explain the semantic processing for the second function of the ontological module, which is the similarity in diagnosis, e.g. to recommend a doctor or specialist according to diagnosis evaluated by another doctor. This process is to know which doctors or specialists have treated several patients. Therefore, we explore the ontology to find the concept associated with a doctor, if it is found, patients associated with that doctor are extracted, and if exists the specialists that have examined the patient. We

compared the diagnosis given by each doctor to each one of these patients and if exist a similarity suggests which specialist or doctor is the indicated.

The system displays in graphical form the associations among these concepts to assist in decision making by medical staff and view description of each instance associated with the concept (e.g. Dr. Perez associated with the concept Doctor). In the next section the results are shown.

5 Experiments and Results

The experiments were performed using cell phones Sony Ericsson w580 and Motorola 810. According to the following roles of user: patients, doctors or paramedic. We started by explaining the functions addressed to patients for mobile and web. The first test was to register a user (administrator, paramedic or patient) for them to logon and typing the required data into a web form, as shown in Figure 3.

Fig. 3. User registration on Web

After user has been registered a identification card (ID) is generated and it is sent by Bluetooth to cell phone of user, the result of this operation is shown in Figure 4.

Fig. 4. Medical carnet reception

As shown in Figure 2, data from the medical card is received and displayed on the user's cell phone. Now we explain the testing for role of user: doctors. In this case the patient's medical card is explored from a Web form where the doctor can know the various treatments that have been applied to patients for a specific disease. This query is not processed from a database, but is performed through the SPARQL language using the concepts stored in the ontology. The difference is that the concepts are structured for performance the role of a medical assistant. The results displayed will facilitate the decision making according to treatment assigned to patients. The web interface of this process is shown in Figure 5.

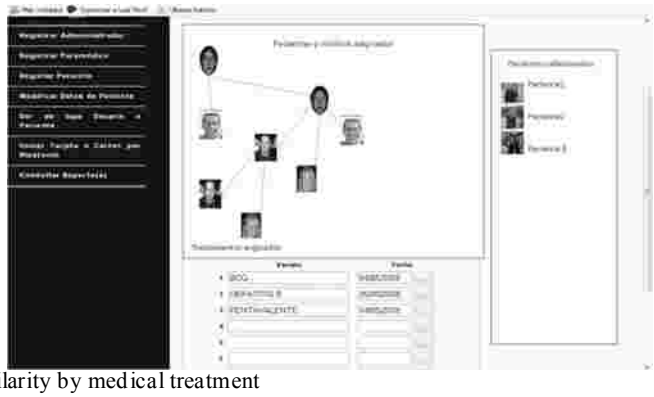

Fig. 5. Similarity by medical treatment

As shown in Figure 5, the relationship between patients and doctors are shown, and when a patient is selected, the various medical treatment received (medical history) are displayed, moreover, shows the related patients, e.g. patients with diseases in common and have been treated by the same or doctors or specialists. The treatments are compared conceptually (semantic similarity) For example, medicaments can be supplied with different names but they containing the same chemical substance) that

can find out by semantic similarity, where the ontology is assisted by a taxonomy of medicaments and chemical substances. The concepts of such medicaments have instances (chemicals substances). Thus, according to the degree of similarity between medicaments and treatments provided to assigned patients. The system gives suggestions on treatments for a particular disease.

Another function offered by the system is to suggest a specialist or physician for a particular disease, according to the diagnosis given by doctor who reviewed. This compares assigned diagnosis and treatments for a disease, in different patients. Figure 6 shows the interface for this process.

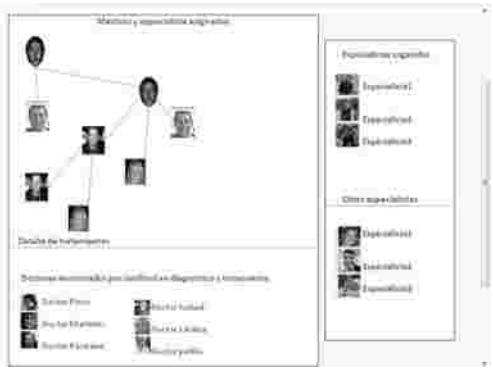

Fig. 6. Suggestion of a medico or specialist

The comparison of diagnoses and treatments were performed by identifying the same disease in different patients, compare the concepts representing the treatment and diagnosis, if a matching is found the doctors or specialists associated with them are suggested as candidates appropriate to treat the patient.

Moreover, the patient registration needs to provide medical information to be stored into medical carnet. Personal data are entered and information about diseases and allergies of patient. After patient registration the carnet is generated and sent to his/her cell phone. When paramedic is on a emergency, he establishes communication with the patient's cell phone and access to patient's carnet, generating the corresponding report, according to vital signs, treatments provided, and the material used. Applications installed on the cell phones of the paramedic and patient using a security code required to ensure safety in the transfer of confidential information. This is shown in Figure 7.

Fig. 7. Carnet transferring

Furthermore, reports include register vital signs such as temperature and pressure. Additionally, the medicines and materials used in the event. To complete the report paramedics provides the location data of the event. This is shown in Figure 8.

Fig. 8. Report view

In addition, paramedics can enter their reports to the system and to query previous reports. The session is started with Bluetooth communication by sending the digital ID, and SSL protocol to increase system security. Figure 7 shows the result of the transfer and registration of a report in the web application.

Fig. 9. Report transfer

6 Conclusions

We present a system to manage the patient's medical history and treatments received by using a digital medical carnet. Provide suggestions for possible treatments and which doctors and specialists are recommended to treat patients. This process is supported by the semantic similarity. Ontologies contain concepts that represent diseases, treatments, and the relationships among these, patients and doctors. The patient's medical card (medical history) is transferred via Bluetooth. The results were as expected according to the functionality and operation of a traditional medical card (on paper) which is used in clinics and hospitals. Also, the suggestions and recommendations of doctors and treatments facilitate decision-making to doctors and specialists in clinics and hospitals

According to the results consider the following future work:

- Extend the use of digital signatures to documents used across mobile and web applications.
- Integration of other mobile devices with Bluetooth to monitoring the condition of a patient.
- Include more concepts and relationships in the ontology to be able to pre-diagnosis
- Include a model of semantic processing in the cell phone to make suggestions of doctors and treatments through a mobile application.

References

1. http://www.inegi.org.mx/est/contenidos/espanol/rutinas/ept.asp?t=tinf220&c=9194
2. Paul J. Camp , James M. Hudson , Russell B. Keldorph , Scott Lewis , Elizabeth D. Mynatt, "Supporting communication and collaboration practices in safety-critical situations," *CHI '00 extended abstracts on Human factors in computing systems,* April 01-06, 2000, The Hague, The Netherlands
3. N. Bricon-Souf and C. R. Newman, "Context awareness in healthcare: A review," *Intl. journal of Medical Informatics* 76, 2--12, 2007.
4. V. Stanford, Beam me up, Dr. McCoy, IEEE Pervasive Comput. Mag. 2 (3) (2003) 13-18.
5. M. Munoz, M. Rodriguez, J. Favela, A. Martinez-Garcia, V. Gonzalez, Context-aware mobile communication in hospitals, IEEE Comput. 36 (9) (2003) 38-46.
6. S. Mitchell, M.Spiteri, J. Bates, G. Coulouris, Context aware multimedia computing in the intelligent hospital, in: Proceedings of yhr Ninth ACM SIGOPS European Workshop, Denmark, September 200
7. M. Munoz, V. González, M. Rodríguez and J. Favela "Supporting context-aware collaboration in a hospital: An ethnographic informed design," *lecture notes 2806.* Springer, New York, NY, 330-344
8. Stephanos Androutsellis-Theotokis , Diomidis Spinellis, "A survey of peer-to-peer content distribution technologies," ACM *Computing Surveys* (CSUR), v.36 n.4, p.335-371, December 2004
9. H. Bludau and A. Koop, "2002. Lecture Notes in Informatics: Mobile Computing in Medicine," *Kellen Verlag.*
10. Jonas Landgren and Urban Nulden, "A study of emergency response work: patterns of mobile phone interaction," in *Proc. 2008 ACM Conference on Computer Supported Cooperative Work*
11. Kjeldskov and M. Skov., "Supporting work activities in healthcare by mobile electronic patient records," in *Proc. 2004 6th Asia-Pacific Conference on Human-Computer Interaction*
12. http://www.sciencedaily.com/videos/2006/0306-medical_records_on_your_cell_phone.htm
13. http://www.bluecove.org/
14. http://www.jornada.unam.mx/ultimas/2008/11/01/diabetes-males-del-corazon-y-accidentes-causan-56-de-muertes-en-mexico-inegi
15. http://www.avetana-gmbh.de/avetana-gmbh/produkte/jsr82.eng.xml