Available online at www.sciencedirect.com
ScienceDirect
Procedia Computer Science 83 (2016) 90 – 97
Procedia Computer Science

The 7th International Conference on Ambient Systems, Networks and Technologies (ANT 2016)

Patient Monitoring System Based on Internet of Things

Jorge Gómez[a], Byron Oviedo[b] , Emilio Zhuma[b,]*

[a]*Universidad de Córdoba, Departamento de Ingeniería de Sistemas, Montería- Colombia*
[b]*Universidad Técnica Estatal de Quevedo, Facultad de Ciencias de la Ingeniería, Quevedo - Ecuador*

Abstract

The increased use of mobile technologies and smart devices in the area of health has caused great impact on the world. Health experts are increasingly taking advantage of the benefits these technologies bring, thus generating a significant improvement in health care in clinical settings and out of them. Likewise, countless ordinary users are being served from the advantages of the M-Health (Mobile Health) applications and E-Health (health care supported by ICT) to improve, help and assist their health. Applications that have had a major refuge for these users, so intuitive environment. The Internet of things is increasingly allowing to integrate devices capable of connecting to the Internet and provide information on the state of health of patients and provide information in real time to doctors who assist. It is clear that chronic diseases such as diabetes, heart and pressure among others, are remarkable in the world economic and social level problem. The aim of this article is to develop an architecture based on an ontology capable of monitoring the health and workout routine recommendations to patients with chronic diseases.

Peer-review under responsibility of the Conference Program Chairs

Keywords: Internet of Things, Ontology, E-Health, Context Awareness

* Corresponding author. Tel.: 57 3103556122;
E-mail address: jegjorge@gmail.com

Peer-review under responsibility of the Conference Program Chairs
doi:10.1016/j.procs.2016.04.103

1. Introduction

Today increasingly growing number of people with chronic diseases, this is due to different risk factors such as dietary habits, physical inactivity, alcohol consumption, among others. According to figures from the World Health Organization, 4.9 million people die from lung cancer from the consumption of snuff, overweight 2.6 million, 4.4 million for elevated cholesterol and 7.1 million for high blood pressure . It is said that in the next 10 years, deaths from chronic diseases will increase by 17%, which means in figures of about 64 million people[1], Chronic diseases are highly variable in their symptoms as well as their evolution and treatment. Some if not monitored and treated early, they can end the patient's life. Among the most common chronic diseases that can be treated and monitored are diabetes, blood pressure, cardiac arrhythmia[1] Patients with these diseases besides having limitations in their physical condition, also often have economic, emotional and social relations problems, among others[2].

Patients often take time to adapt and accept the reality of disease long-term because disability. Reason whereby this group of people with these diseases must have constant monitoring by your doctor to discuss the state of it and set the appropriate treatments. For many years the standard way of measuring glucose levels, blood pressure levels and heart was with traditional exams in a specialized health center. Thanks to technological advances in today there is great variety running sensor reading vital signs such as blood pressure cuff, glucometer, heart rate monitor, including electrocardiograms[3], which allow patients to take their vital signs daily.

Although the main objective of these readers is that patients know their vital signs daily, there is reason to be second on the list of priorities when taken daily shows, and is to be stored consistently results which shed daily tests so they can be the subject of medical studies. Similarly also the readings that do permanently to patients reports, doctors recommend you also workout routines that allow them to improve the quality of life and overcome such diseases[4]. The internet of things applied to the care and monitoring of patients is increasingly common in the health sector, seeking to improve the quality of life of people.

The concept of Internet of things is recent and is defined as the integration of all devices that connect to the network, which can be managed from the web and in turn provide information in real time, to allow interaction with people they use it[5] . Another concept of IoT "is the general idea of things, especially everyday objects, which are readable, recognizable, locatable, addressable and controllable via the Internet - either through RFID, wireless LAN, wide area network, or by other means "[6]. IoT The term itself was first mentioned by Kevin Ashton in 1998 and aims at the exchange of information[7]. On the other hand[8], the Internet of things can be seen from three paradigms, which are Internet-oriented middleware, things sensors oriented and knowledge-oriented semantics. Therefore, it is appropriate, such delimitation because the interdisciplinary nature of the subject. However the usefulness of the IoT is reflected when crossing between the three paradigms in the development of applications[9]. The Internet of Things has a number challenges that are still working. As in the hardware layer, whose purpose is to allow the interconnection of physical objects using sensors and related technologies. The challenges associated with this layer are related to miniaturization, while today there are devices with storage, processing, internal parts should be smaller and to improve efficiency. In the case of the sensors used to measure diabetes, EKG, blood pressure, among others, are not very precise and its size is very large and consume a lot of power. Another challenge is found in the communications layer, which is tasked billion devices connected to the network, which involves improving bandwidth and the electromagnetic spectrum. Faced with the above from the application layer and services are presented countless possibilities that allow to obtain, process and recommend valuable information for patients to treatment of diseases and improve their lifestyles.

According to the above, it is necessary to take advantage of the benefits that come with advances in technology such as the Internet of Things, as they have become an important medium for the transfer of data from any hardware platform, allowing full communication Person to Person[10] (P2P) and machine to machine[11] (M2M), to improve health care for chronic patients.

The main purpose of this work is to develop a solution based on an ontology with ability to monitor the health status and recommendations of workouts with chronic diseases architecture. This paper is organized as follows, related work, architecture developed, case study, and conclusions.

2. Related works

The area of health in recent years has been rapidly integrating technology in the monitoring, diagnosis and treatment of patients remotely and in situ. Thus achieving to improve the quality of life of patients and greater traceability of information from them. Most studies reviewed point to a chronic disease monitoring in particular as in[12,13,14] which are responsible for the first one monitoring sleep through gyroscope Smartphone, the second remote monitoring of vital signs and the third of a telemedical ECG system of a patient.

All these systems although quite complete is your scenario, include individual problems with regard to the treatment of some diseases that affect human being in the economic and social. Is a very important way to develop a comprehensive solution where no matter what kind of disease, the type of check, the different units to be handled this can become a possible solution for sequential monitoring of these patients.

Other systems have found special features which make use of their development, in the case of[15], which developed a prototype device electrocardiography, which integrated with a Smartphone for displaying results. In[16], in this system were layers below and decided to develop architectures for such systems, such as those proposed an architecture for the development of a telemedicine system applied for ECG monitoring with remote access.

Within these systems can be found also see the development of some of these dedicated to patient care through telemedicine is the case[17] that through interactive media and development of alternative technologies contribute to improved consultation and clinical monitoring, as well as some related to health care from home as[18] who proposed a terminal for the integration of medical services from home using external sensors for measuring vital signs.

Although[19] also integrate external sensors measuring vital signs, this has linked to structural health monitoring SHM approach, under a proposed scheme to eliminate environmental effects of IoT environments.

Other systems such as those proposed in[20] are fixed in the IoT bring advantages in terms of perception, transmission and application of information in the field perspectives of health and medical care. Enabling smart, an accessible and communication system based on IoT hosting segments such as: medical equipment, information management control medication of patients, telemedicine, mobile medical care, and personal health management, among others. Some teams that were responsible for analyzing and developing monitoring systems of diabetic patients based on IoT IPV6 with a type of connectivity, making noninvasive patients measurements with this disease, which would provide a better approach to the interpretation of these measurements were also found by the specialist s in the field.

3. System architecture

3.1 Context model

For the development of the context aware internet and integrated systems of things, there are several investigations that point of user interaction with the context. Given that there are various definitions of context that vary according to their applications in computer science and the position of the authors. According to[21]: the context divided into three categories which correspond to:

1. Context computer (network connectivity, communication costs, communication bandwidth, and nearby resources such as printers, displays, stations).
2. Background user (user profile, location, nearby people, including the current social situation).
3. Physical context (power, noise levels, traffic conditions, temperature). They add a fourth category that involves time, because it is important time of day, the week, the season, etc. And

consequently a context over a period of time; mention an additional element, the history of context.

Defines the context as any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves[22].

To model knowledge based on paradigms proposed by[8] in the Internet of Things, there are different alternatives such as ontologies that enable sharing knowledge because they provide a formal specification of the semantics of context data, allowing different heterogeneous entities and distributed and ubiquitous mobile environments, to exchange context information of users[23]. Ontological approaches based on the use of language OWL, improve the support of automated reasoning, allowing the representation of complex data; providing a formal semantics for context data for sharing and / or integrate context from different sources; providing tools of reasoning to check the consistency of a set of relationships that describe a contextual situation. Finally, the most important, the characterization of a more abstract context from the recognition of a set of contextual data and their interrelationships, for example, recognize user activity automatically[23,24].

For purposes of this investigation was implemented an ontology, which allows inferences about the behavior of context. Namely according to the patient interaction you have with the context, the system will be able to offer measurement routines of their illnesses and workouts to be carried out, based either on location, profile, time and date. The same device allows communication between machine - machine, ie (sensor - smartphone, tablet, audio) and smart phone user.

In the case of machine to machine, according to the inferences made by the server and given the temporal context, the system sends information via Bluetooth audio device found in the home of the sick person, to emit a message informed where a glucose uptake which is optionally diabetic or other measurements should be made. This same technique is used to hearing so inform the patient about his workout routine. The system is able to adjust the workout routines, measurement and interfaces according to the type of disease to be monitored. For example, a patient wakes up at 7:00 am, the time context based system immediately will be presented visually and hearing on the smart phone using the audio devices you have configured within your home, readings to be performed in the morning, in Figure 1 shows how the ontology model.

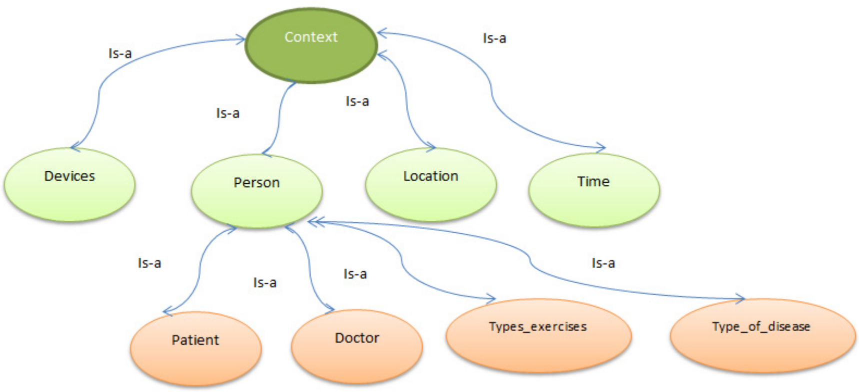

Fig. 1. Context model.

Next is describing the ontology components.

- Person: This entity corresponds to an individual within the system, which can be a doctor or a patient. If Doctor information related to their profession and their skills in the care of chronic diseases and to treat such patients will treat. In the case of the patient was taken as reference profile, the information associated with their illnesses, medications workouts routines, skills eating habits, among other risk factors. Likewise, there is control on measurements performed daily to monitor their conditions.

- Time: This is the time in which the patient interacts with the system either because it has an activity of a workouts routine and measuring some of their diseases. Time can be aimed at a particular time, a date or a specific period such as a medical appointment with a health specialist.
- Devices: These are mobile devices used to interact patient with the context. Within the information they provide is the GPS devices support, BLE (Bluetooth Low Energy), the first location for outdoor environments and the second for indoor location and communication with audio devices that allow you to listen to auditory information to the patient.
- Type_of_disease: Refers to all chronic diseases with which the patient is connected, diagnoses, treatments, risk factors and others.
- Type Exercises: Corresponds to control the workout routines that the patient according to the kinds of chronic diseases that possess to perform.
- Location: is the location of the patient, in and out of your home, clinic or hospital. The system is able to adjust the location-based information, the GPS coordinates for this is taken in outdoor environments to indoor environments and works with BLE sensors associated with bedrooms, living rooms, bathrooms, kitchens, among others, such interaction is implicit and is achieved from machine to machine.

3.1 Architecture performance

The architecture developed operates under the philosophy of client/server in Fig. 2, it shows the distribution of architecture. Here are the features of the components of the server and client will be described.

- Server: The server consists of three basic components:
- Detector context: is the component responsible for obtaining context information. The information is captured through the answers given by the web services that make communication available between the server, the database patients, types of workouts, illness and doctors.
- Reasoning engine: It is in charge of making inferences based on the contextual information provided by the detector context. Ontology used to make recommendations as workout routines to patients and inform that moment readings are at knowledge layer. These inferences make through OWL and SWRL (Semantic Web Rule Language)[25].
- The server (Apache Tomcat), due to requests from web service is consumed naturally by the mobile client, which in this case is the smartphone of the patient, which makes applications according to the interaction that is being generated at the time with the context.

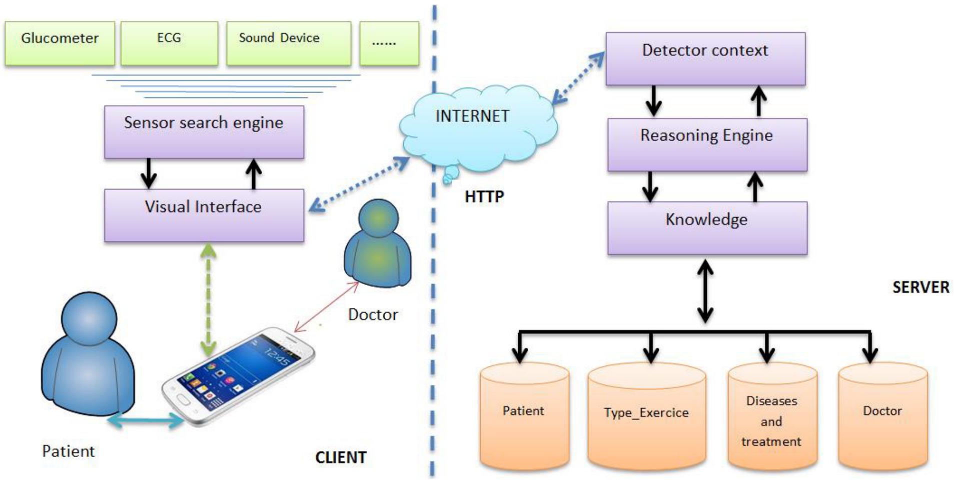

Fig. 2. Architecture of system

- Client: is a system developed on Android 4.4, which consists of two main layers are the Visual Interface, which makes regular web server invocations, the presents on the screen as the event that requires the interaction with the patient, namely, a reading of blood pressure, blood glucose meter among others. In the event that is to take a reading, the search engine sensor is activated to acquire the data and inform the patient hearing that the readings and workout routines to be performed must be done. Meanwhile the doctor can check the history of the patients. Given the circumstances of the patient readings are outside the normal range, the system sends alert notifications to the doctor where he reports on the readings obtained by the patient.

4. Case study

To validate the efficiency of the system is used in patients with diabetes and heart arrhythmia. For this, a sample of 16 people which used the system for a month, each measuring sensors had diabetes, and EGC, Bluetooth audio devices to broadcast audio guide was made to take readings and workout routines, in addition to containing the smartphone application. In figures. 3 and 4 can be seen interface patient monitoring.

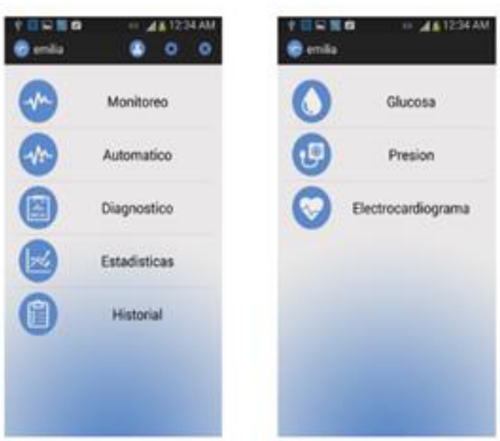

Fig 3. Patient Application Options and Monitoring Option

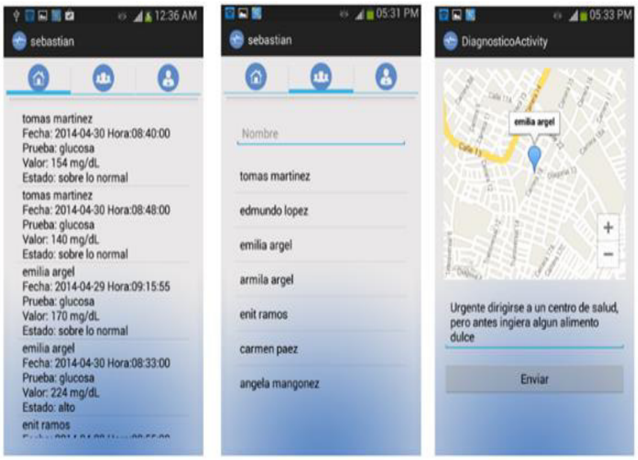

Fig 4. Patient Application Options and Monitoring Option

This group of people was given an induction system operation and were allowed to monitor the state of your health. At the end of the week they will be applied based on the Likert scale test, which is a scale commonly used to measure the degree of satisfaction of the system. It based on the Cronbach's alpha[26], which is a psychometric coefficient normally used to measure the reliability of a system on a scale of measurement analysis. The results of the satisfaction survey can be seen in Table 1.

Table 1. Questionnaire applied to patients.

	Question	Score	SD
1	Listings emitting system according to readings from sensors, allow you to be careful with your health	4,0625	0,853912564
2	Doctors give timely response to their diagnosis according to the reading obtained by the sensors	4	0,73029674
3	You think that the system allows you to improve your quality of life, because he permanently suggests that care should have and exercise routines to follow.	4,0625	0,5
4	The system allows you to provide quick help in case required	4,25	0,4472136
5	The interface provided by the system is intuitive, easy to use	4,375	0,5
6	The statistics generated by the system lets me know about my records are important in my diagnoses	4,4375	0,51234754
	Cronbach Alph		0.7101

Faced with the results obtained by the instrument and with a Cronbach's alpha equal to 0.71, it can be concluded that patients perceive the system developed is a tool that allows them to monitor their health and helps them to keep it, with the suggestion that generates, either by the same system or the physician assigned to your case, besides the workout routines.

5. Conclusion

The system developed patient monitoring based on Internet of things, is an alternative that can be used to help patients with chronic diseases. Likewise with this set of solutions the aim is to improve the quality of life of patients, not just monitoring them, but also to enable direct them to improve their eating habits and workout routines.

The context model developed for the system proved to be efficient when making inferences related to the context, such as recommendations for taking measures through sensors, as well as recommendations and workout routines tips to improve the eating habits of patients.

Acknowledgements

This project was funded by the University of Cordoba, according to the project No. F1-07-15. Special thanks to the House for allowing Monteria Diabetic test the system. Also, thanks to the Universidad Técnica Estatal de Quevedo.

References

1. OMS, Overview - Preventing chronic diseases: a vital investment, http://www.who.int/chp/chronic_disease_report/part1/en/, visited, november 2015.
2. Who, J., & Consultation, F. E. Diet, nutrition and the prevention of chronic diseases. *World Health Organ Tech Rep Ser*, *916*(i-viii), 2003.
3. Swan, M. Sensor mania! the internet of things, wearable computing, objective metrics, and the quantified self 2.0. *Journal of Sensor and Actuator Networks*, *1*(3), 217-253, 2012

4. Strollo, S. E., Caserotti, P., Ward, R. E., Glynn, N. W., Goodpaster, B. H., & Strotmeyer, E. S. A review of the relationship between leg power and selected chronic disease in older adults. *The journal of nutrition, health & aging*, *19*(2), 240-248, 2015.
5. Gómez, J., Huete, J. F., Hoyos, O., Perez, L., & Grigori, D. Interaction System based on Internet of Things as Support for Education. *Procedia Computer Science*, *21*, 132-139, 2013
6. National Intelligence Council. Disruptive Technologies Global Trends 2025. Six Technologies with Potential Impacts on US Interests Out to 2025. 2008. Available online: http://www.fas.org/irp/nic/disruptive.pdf (accessed on 19 November 2015).
7. Feller G. Understanding the Three Basic Layers of the Internet of Things. Bankinter Foundation of Innovation. accessed September 2015, http://www.fundacionbankinter.org/system/documents/8193/original/Chapter_3_Understanding_the_three_basic_layers.pdf, 2011.
8. Atzori, L., Iera, A., & Morabito, G. The internet of things: A survey.*Computer networks*, *54*(15), 2787-2805, 2010
9. Gubbi, J., Buyya, R., Marusic, S., & Palaniswami, M. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, *29*(7), 1645-1660, 2013.
10. Jermyn, J., Jover, R. P., Murynets, I., Istomin, M., & Stolfo, S. Scalability of Machine to Machine systems and the Internet of Things on LTE mobile networks. In *World of Wireless, Mobile and Multimedia Networks (WoWMoM), 2015 IEEE 16th International Symposium on a* (pp. 1-9). IEEE, 2015.
11. Chung, K., Kim, J. C., & Park, R. C. Knowledge-based health service considering user convenience using hybrid Wi-Fi P2P. *Information Technology and Management*, 1-14, 2015.
12. Fahim, M., Vui, L. B., Fatima, I., Lee, S., & Yoon, Y. A Sleep Monitoring Application for u-lifecare Using Accelerometer Sensor of Smartphone. In *Ubiquitous Computing and Ambient Intelligence. Context-Awareness and Context-Driven Interaction* (pp. 151-158). Springer International Publishing, 2013
13. Ryan, R. H. *U.S. Patent No. 9,005,120*. Washington, DC: U.S. Patent and Trademark Office, 2015
14. Dubner, S., Auricchio, A., Steinberg, J. S., Vardas, P., Stone, P., Brugada, J., ... & Zareba, W. ISHNE/EHRA expert consensus on remote monitoring of cardiovascular implantable electronic devices (CIEDs). *Annals of Noninvasive Electrocardiology*, *17*(1), 36-56, 2012.
15. Kang, S., Kwon, S., Yoo, C., Seo, S., Park, K., Song, J., & Lee, Y. February). Sinabro: opportunistic and unobtrusive mobile electrocardiogram monitoring system. In *Proceedings of the 15th Workshop on Mobile Computing Systems and Applications* (p. 11). ACM, 2014.
16. Andrada, D., Sparhakl, P. M., Novillo, H. M., & Ierache, J. Arquitectura para el monitoreo remoto de funciones vitales en pacientes ambulatorios. In *XII Congreso Argentino de Ciencias de la Computación*.
17. Alvez, R. (2011). Aplicación de telemedicina para la mejora de los sitemas de emergencias y diagnósticos clínicos. *Memoria de Trabajos de Difusión Científica y Técnica*, (9), 91-97, 2006
18. Pang, Z., Zheng, L., Tian, J., Kao-Walter, S., Dubrova, E., & Chen, Q. Design of a terminal solution for integration of in-home health care devices and services towards the Internet-of-Things. *Enterprise Information Systems*, *9*(1), 86-116, 2015.
19. Zhang, H., Guo, J., Xie, X., Bie, R., & Sun, Y. Environmental effect removal based structural health monitoring in the internet of things. In*Innovative Mobile and Internet Services in Ubiquitous Computing (IMIS), 2013 Seventh International Conference on* (pp. 512-517). IEEE, 2013.
20. Hu, F., Xie, D., & Shen, S. On the application of the internet of things in the field of medical and health care. In *Green Computing and Communications (GreenCom), 2013 IEEE and Internet of Things (iThings/CPSCom), IEEE International Conference on and IEEE Cyber, Physical and Social Computing* (pp. 2053-2058). IEEE, 2013.
21. Schilit B., Adams N., Want R. (1994). Context-aware computing applications. IEEE Workshop on Mobile Computing Systems and Applications, Santa Cruz, USA, 1994.
22. Dey, A.K. Understanding and Using Context. Personal and Ubiquitous Computing Journal 1(5), 4–7, 2001.
23. Bettini, C., Brdiczka, O., Henricksen, K., Indulska, J., Nicklas, D., Ranganathan, A., & Riboni, D. A survey of context modelling and reasoning techniques. Pervasive and Mobile Computing, 6(2), 161-180, 2010.
24. Perera, C., Zaslavsky, A., Christen, P., & Georgakopoulos, D. (2014). Context aware computing for the internet of things: A survey. Communications Surveys & Tutorials, IEEE, 16(1), 414-454, 2014.
25. SWRL, A. Semantic Web Rule Language Combining OWL and RuleML.*W3C Member Submission, http://www. w3. org/Submission/SWRL/, 2004*
26. Wessa, P. Free Statistics Software, Office for Research Development and Education, version 1.1.23-r7, URL http://www.wessa.net/, 2016.