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Escuela Internacional de Posgrado

Proyecto de Tesis Doctoral **(Plan de Investigación)**
Doctorando/a:
Apellidos y nombre: ALAWADI, SADI ABED ALHALEEM MOHAMMAD DNI/Pasaporte: **I969712 / NIE: Y0853763V** Correo electrónico: saadiabadi@gmail.com **Firma**  *(Puede incluir la firma digitalizada)*
Título provisional de la Tesis Doctoral: **Wireless sensor networks applied to the development of AAL and health care systems** Programa de Doctorado en el que solicita la admisión**:** **Desorillo de software** Línea de Investigación: Departamento de Presentación (no completar en programas de doctorado del RD1393/2007)**:** **Desorillo de software**
Explique brevemente la relación entre la temática de su tesis doctoral y el programa de doctorado en el que solicita la admisión:

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[1] Cada uno de los directores deberá acreditar, al menos, un sexenio de investigación (*no es necesario en el caso de profesores de la Universidad de Granada y así figure en su expediente del Servicio de Personal*), y en su defecto, deberá adjuntar, al menos, cinco artículos de investigación de calidad, y un informe razonado del Consejo de Departamento o Instituto Universitario en el que se acredite su experiencia investigadora y su idoneidad para la dirección del trabajo de tesis propuesto.

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Se seguirá el siguiente esquema:

- Título.
- Introducción. Incluir el estado del arte en el tema de la tesis.
- Justificación. Razones para realizar ese estudio.
- Hipótesis. Responder a la pregunta ¿qué quiere demostrar esta tesis?
- Objetivos. Tanto el objetivo general como los específicos que se pretenden alcanzar.
- Plan de trabajo. Describir el plan de actividades a realizar y una temporalización de las mismas. En el caso de tesis experimentales, aportar el diseño experimental con descripción de los experimentos y sus variables.
- Metodología. Describir la metodología que se van a aplicar para lograr los objetivos.
- Referencias bibliográficas utilizadas para elaborar el proyecto de tesis.

1. Title

Wireless sensor networks applied to the development of AAL and health care systems

2. Introduction

Nowadays governments spend a lot of money on Healthcare, but with the current economic crisis at its peak, countries face a very difficult financial situation, and all governments in the world are working on changing their economic policy to try to get out of the crisis. The constant increase of old people further complicates the financial problem and puts a strain on national health systems **[Kelton, 2007].** Today, the percentage of old people is much higher than before, and the majority of them are either living by themselves or with an old mate. Old persons face many difficulties because of the state of their health, and they try to look after their health visiting frequently the doctor or employing a nurse at home: the first one requires an overuse of public health resources implying much time and effort, and the second one is very expensive **[Zapata, 2012].** Furthermore, many elderly persons suffer from chronic diseases that make difficult their easy movement and their access to the external world without help **[DeVol, 2007].**

Each of them needs a caregiver to meet their needs, and in the next few years there will not be enough human resources equivalent to the number of elderly people in order to provide them with the health care they need. Moreover, caregivers need monthly salaries and other expenses, adding further strain on economies in crisis. To contribute in the reduction of the huge costs of National Health Services we need to focus on technology and find technological solutions that can provide healthcare for elderly persons and the society at large, relieving caregivers to attend the tasks more urgent and save health resources at the same time **[Kelton, 2007].**

Taking all the above in consideration all researchers have focused on how to best solve problems of elderly persons with the minimum costs and high efficiency. The solution involve using computer technology and in extension the Information and Communication Technologies (ICT) are critical to provide control over the elderly while giving them confidence in their life and home without direct physical human intervention. The researchers are mainly oriented in two complementary areas, ambient assisted living (AAL) and telemedicine.

AAL is concentrated on the concepts, products and services which improve the interaction between technical and social systems, with the objective of increasing quality of life of people,

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especially in areas related with the independent living, their autonomy and self-confidence **[www.spade.be, 2011][Gaßner, 2010][Leonardi, 2008]** . The technological solutions are based on the use of smart assistant systems capable of controlling and monitoring the health state (physical or mental), the autonomy or the security of people (e.g. elder people). In contrast, telemedicine is focused on the use of telecommunication and information technologies in order to provide clinical health care at a distance. It helps eliminate distance barriers and can improve access to medical services that would often not be consistently available in distant rural communities. It is also used to save lives in critical care and emergency situations. **[Ipiña, 2010][Hanak, 2007].** The main concept of telemedicine is to provide medical services from a distance without the attendance of a doctor. Telemedicine has the advantage of reducing the time and cost of providing care to patients, while any patient can still receive high quality medical service under the supervision of doctors located anywhere in the world **[Currell, 2000].**

There are different alternative approaches to develop AAL or telemedicine systems based on the development of proprietary appliances, distributed systems, agents, mobile devices, and so on **[Wojciechowski, 2008] [Hanak, 2007] [Kaufmann, 2012].** One of the most reliable approaches is based on wireless sensor networks (WSN). A wireless sensor network is a collection of small, cheap and smart sensors (motes) which are connected to a base station using a wireless network **[Dembowski, 2010].**

The basic applications are oriented towards the acquisition of large quantity of data from a self-organized network composed on large quantity of geographically dispersed motes, which, moreover, should continue to operate for years without maintenance. WSN technology has been applied successfully to AAL applications for years **[Alemdar, 2010],** profiting especially the capabilities of monitoring of these systems; i.e., we can perform the main medical tests and collect the results using sensors in the wireless network, and then we can determine automatically a general report of the elderly person on our device and control the health status without a lot of human effort.

Recently, a special WSN, the wireless body area network (WBAN), has emerged with the focus on individuals, providing new devices wearable or implantable in the human skin **[Andréu, 2009][Ullah, 2010] [Jung, 2008].** But, in any case, the resulting systems based on WSN or WBAN are always passive in order to save energy and reduce the power consumption of the overall system. Many studies has been performed to optimize the WSN technology with respect to the network (bandwidth, coverage area, low energy, QoS, data protocol …), the power consumption (life cycle of motes), the mote resources (low processing, suspend states, low memory,…), the software infrastructure (operating systems, firmware, middleware) or data security (data integrity, hacking attacks, …) **[Andréu,2009][D'laz, 2005][Römer,2002][Coronato, 2012][Wang, 2008][Lee, 2007][Rahmami, 2005][Lindblom][Domingues,2011].**

AAL systems share some of the goals of WSN; in fact, an AAL system must bring the data captured by the sensors in WSN directly onto a station base where an expert or a health caregiver can supervise, for example, the health status of individuals or elderlies and determine the actions to be executed. But, in AAL, we need smarter devices capable of processing information directly by, for example, fusing data from several data sources, which, in contrast, suppose more power consumption. The AAL systems should be more reactive in order to take automatic decisions when an individual physical risk can be happening. The energy saving should be a goal not only for the design of the network protocol, but also for the development of the software. Thus, software components must be lightweight in the use of node resources (i.e., frequent suspend

cycles). In addition, an AAL system must coordinate and control a huge number of heterogeneous devices, in many cases through different network protocols (not only WSN). Then, effective integrating mechanisms should be imposed on the systems with the purpose of sharing the information captured on surrounding environments among devices, especially on devices with a control role into the system (users or smart devices). Complementing the above, an adequate management of real time constraints is important to guarantee the execution of the system in real-time, beneficing of a better responsiveness to anomalous or risk situations.

3. Justification

AAL and health care systems have a justified demand according to past and recent framework programs of European Union and the largest population growth in Europe in coming years. Our proposal in this work is to investigate the use of WSN for the development of AAL system with a dual purpose. First, we want to study the technical possibilities offered by the WSNs to monitor the surrounding environment (e.g. the physical state of an elderly person) with reactive capabilities without increasing the demand for network resources at network level and at application level, and thus, maintaining the energy saving. Second, the integration capacity of WSN in larger networks, LAN and/or WAN networks allows the propagation of critical information among networks with the urgency required by the experts. This supposes raising the physical data obtained from multiple sensors to an abstract interacting space, the ubiquitous space, in which the applications, users and devices can reason the correct operation of the system in any case (in our case to help elderly or person with disease).

4. Hypothesis

As starting point of this work we want to find technological solutions to some of the problems presented in above sections with respect to AAL and health-care systems related to some of the projects in which the research group is involved. This work aims to investigate the potential of WSNs to enable collaborative tasks sharing the information and data acquired from the environment among fixed, mobile or wearable heterogeneous devices, some of them with extremely resourceful constrained powered by batteries.

We want to demonstrate that a WSN can be included in an ubiquitous space as a part of the system, allowing the interactions among devices, users and applications transparently. The collaboration among devices from a WSN domain with non WSN domain should be performed and managed by the ubiquitous space without reification. Since health-care systems requires to be dependable and, in many case, compliant with real time constraints, we will investigate the consequences of applying the real-time theory for the development and real-time execution of applications.

We expect that this work can contribute to the definition and progress of a new platform specific for AAL and health-care systems. This platform will provide a methodological frame for the definition, modeling and development of these applications.

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5. Objectives

The main objective of this work is to investigate from a technical, formal and methodological standpoint how the use of wireless sensor networks and their integration into a scalable heterogeneous ubiquitous space could be beneficial for the development of smart, autonomous and reactive applications on AAL and health care systems.

To achieve this goal we must accomplish the following specific objectives such as:

- Identify the challenges of the health care systems comparing and analyzing the solutions applied to date.
- Investigate the WSN limitations and focus on the differences between the WSN protocols, the standards and the way to integrate them.
- Analyze the techniques and protocols applied on WSN to achieve an improvement of the energy saving and the limited resources of motes, and select the best ones for the platform to be developed.
- Design a middleware based on service oriented architecture (SOA) adaptable to WSN standards for WSN that can be deployed on motes and can be integrated into an ubiquitous space.
- Build a framework for the fast development of health-care systems.
- Disseminate the works carried out on this research in journals and workshops.

6. Research Plan

The work plan is the following:

1. Study the technical features of wireless sensor networks for WPAN, especially based on zigbee, IEEE 802.15.4 or Bluetooth among others. Analyze the requirements in terms of hardware and software currently available in the market as well as their potential impact on AAL and health care systems (2 months).
2. Investigate the techniques employed on WSN to optimize the node resources and energy saving such as the data compression, data fusion and other data delivery schemes, the network topology and routing protocols, the scheme of the oriented communications, and so on (4 months).
3. Revise distributing paradigms, middleware's and operating systems based on events which could be used to develop the services platform on WSN domain (4 months).
4. Identify the challenges of health care and AAL systems in general and define the requirements, functionality, constraints and resources required on involved devices (wearable, wireless or wired) (3 months).
5. Analyze the real-time restrictions present in these systems, studying the local scheduling of each node and the global scheduling of the system, the use of real-time communication protocols… and apply a methodology to define the real-time capabilities of applications (3 months).
6. Develop a middleware for WSN systems based on the concept of service orientation adaptable to several WSN standards (4 months).
7. Compare and analyze software infrastructures currently developed for ubiquitous space (including those ones carried out by the research group), and design or adapt a services platform to manage transparently devices, users and applications on the abstract ubiquitous space (3 months).

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8. Build a framework to assist the fast development of health-care systems defining a methodological frame that allows the modeling and implementation of health-care systems (5 months).
9. Test and evaluate the framework (2 months).
10. Write the thesis (6 months).

7. Methodology

The methodologies used to achieve the set of objectives are theoretical and practical. From a theoretical perspective it will be used a methodology frequent in research based on the scientific method, while from a practical perspective it will be used a methodology compliant with software development standards, as well as the application of the software engineering principles.

We will practice

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8. References

Alcaraz, Cristina, Pablo Najera, Javier Lopez, and Rodrigo Roman. "Wireless Sensor Networks and the Internet of Things: Do We Need a Complete Integration?." In 1st International Workshop on the Security of the Internet of Things (SecIoT'10). (2010).

Alemdar, H. & Ersoy, C. "Wireless sensor networks for healthcare: A survey". Computer Networks 54, 2688-2710 (2010).

Andréu, J., Viúdez, J., & Holgado, J. "An ambient assisted-living architecture based on wireless sensor networks". In 3rd Symposium of Ubiquitous Computing and Ambient Intelligence. Springer Berlin/Heidelberg. pp. 239-248 (2009).

Arkin, Esther M., et al. "Data transmission and base-station placement for optimizing network lifetime." Proceedings of the 6th ACM SIGACT/SIGMOBILE International Workshop on Foundations of Mobile Computing, DIALM-POMC. Vol. 10. (2010).

Chatzigiannakis, I., Mylonas, G. & Nikoletseas, and S. "50 ways to build your application: A survey of middleware and systems for Wireless Sensor Networks". 2007 IEEE Conference on Emerging Technologies and Factory Automation EFTA 2007 001907, 466-473 (2007).

Coronato, " A. Uranus: a middleware architecture for dependable AAL and vital signs monitoring applications". Sensors (Peterboroug 12, 3145-61 (2012).

Currell, R., Urquhart, C., Wainwright, P. & Lewis, R. "Telemedicine versus face to face patient care: effects on professional practice and health care outcomes." Cochrane database of systematic reviews Online 97, 35 (2000).

DeVol, Ross C. "An unhealthy America: the economic burden of chronic disease" charting a new course to save lives and increase productivity and economic growth. Milken Institute, (2007).

Diaz, M., Rubio, B. & Troya, J.M. "A coordination middleware for wireless sensor networks" . 2005 Systems Communications ICW05 ICHSN05 ICMCS05 SENET05 377-382 (2005).

Domingues, Jeisa, et al. "An energy-aware middleware for integrating wireless sensor networks and the internet." International Journal of Distributed Sensor Networks 2011 (2011).

Elaheh Rahmani, "Zigbee/Ieee 802.15.4", (2005)

Gaßner, Katrin, and Michael Conrad. "ICT enabled independent living for elderly." A status-quo analysis on products and the research landscape in the field of Ambient Assisted Living (AAL) in EU-27. Berlin: Institut for Innovation and Technology (iit) (2010).

Hanak, David, Gabor Szijarto, and Barnabas Takacs. "A mobile approach to ambient assisted living." Proc IADIS Wireless Applications and Computing Lisbon Portugal (2007) : n. pag.

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Ipiña, Sarralde, Zubia , “An Ambient Assisted Living Platform Integrating RFID Data-On-Tag Care Annotations And Twitter”, Journal of Universal Computer Science, vol. 16, no. 12, 1521-1538 , (2010)

Jung, J., Ha, K. & Lee, J. “Wireless Body Area Network in a Ubiquitous Healthcare System for Physiological Signal Monitoring and Health Consulting”.Pattern Recognition 1, 47-54 (2008).

Kelton, Stephanie. "An Introduction to the Health Care Crisis in America: How Did We Get Here?." Special Series on Health Care. Kansas City, Mo.: Center for Full Employment and Price Stability. September (2007).

Klaus Dembowski, Bryce T. Bradford,” Low Power Wireless Sensor Node”, (2010)

Lee, J.-S., Su, Y.-W. & Shen, C.-C. A Comparative Study of Wireless Protocols: Bluetooth, UWB, ZigBee, and Wi-Fi. IECON 2007 33rd Annual Conference of the IEEE Industrial Electronics Society 46-51 (2007)

Leonardi, C., Mennecozzi, C., Not, E., Pianesi, F., & Zancanaro, M. “Getting older people involved in the process of ambient assisted living research and development”. Gerontechnology, 7.2, 152, (2008).

Manfred Wojciechowski, Jinhua Xiong, “On Context Modeling in Ambient Assisted Living”, WS MRC - HCP-2008 - Third International Conference on Human Centered Processes,13-24 (2008)

Matthais Kaufmann, “Smart Things - Assistance for Ambient Assisted Living”, (2012)

Niclas Lindblom, Iar Systems,” Small, Smaller, Smallest—Rf Communication Protocols For Low-Power Wireless Systems”

O’Flynn, B. et al. “Wireless biomonitor for ambient assisted living”.International Conference on Signals and Electronic Systems Conference Proceedings 257-60 vol.1 (2006)

Perumal.B , Pallikonda Rajasekaran.M, Ramalingam.H.M “ WSN Integrated Cloud For Automated Telemedicine (ATM) Based E-Healthcare Applications”, (2012)

Römer, K., Kasten, O. & Mattern, F. “Middleware challenges for wireless sensor networks” . ACM SIGMOBILE Mobile Computing and Communications Review 6, 59-61 (2002).

Shi, J.S.J. & Liu, W.L.W. “A service-oriented model for wireless sensor networks with Internet” . The Fifth International Conference on Computer and Information Technology CIT05 1045-1049 (2005)

Stojmenovic, Ivan, and Stephan Olariu. "Data-centric protocols for wireless sensor networks." Handbook of Sensor Networks: Algorithms and Architectures (I. Stojmenovic, ed.) : 417-456.(2005)

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Su, Weilian, and Bassam Almaharmeh. "QoS integration of the internet and wireless sensor networks." WSEAS Transactions on Computers 7.4 : 253-258. (2008)

Ullah, S. et al. “A Review of Wireless Body Area Networks for Medical Applications” , SciencesNew York 2, 7 (2010)

Vodjdani, N. “The ambient assisted living joint programme”. 2008 2nd Electronics System Integration Technology Conference 1-2 (2008)

Wang, Lee, Murray “Integrating Sensors With The Cloud Using Dynamic Proxies”, (2012)

Wang, M.-M., Cao, J.-N., Li, J. & Dasi, S.K. “Middleware for Wireless Sensor Networks: A Survey”. Journal of Computer Science and Technology 23, 305-326 (2008).

Zapata , Fernández-Luque, Ruiz ,”Wireless Sensor Network For Ambient Assisted Living”, (2010)

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