Integrating Internet of Things and Cloud Computing for Health Services Provisioning. The Virtual Cloud Carer Project

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***Abstract*— The demographic and social changes are causing a gradual increase of the population in situation of dependency. The main concern of the elder people is their health and its consequences in terms of dependence and also is the primary cause of suffering and self-rated ill health. Since elder people have different health problems that the rest of the population, we need a deep change in national's health policy to get adapted to population aging. This paper describes the preliminary advances of "Virtual Cloud Carer" (VCC), a Spanish national R&D project, whose primary purpose is the creation of new health services for dependents and chronics elderlies, using technologies associated with internet of things and cloud computing.**

Keywords-internet of thing; cloud computing; elderly people.

I. INTRODUCTION

Today, developed countries have great difficulties with effective health services and quality of care in a context marked by the population ageing. This general world trend, that can be seen in Fig. 1, has dramatic effects on both public and private health systems, as well as on emergency medical services, mainly due to an increase in costs and a higher demand for more and improved benefits for users, as well as for increased personal mobility.

This demographic change will lead to significant and interrelated modifications in the health care sector and technologies promoting independence for the elderly. As representative data approximately 60% of the European population (58% in Northern America) is made up of people aged 20 to 64 years, while the 65 and over group covers 19% (16% in Northern America). Thus, there are 3-4 working employees to every pensioner. On the other hand, it is estimated that the 20 to 64 years old group will decrease to 55% and the over 65 group will increase to 28% by the year 2050, making the proportion 1 to 2 instead of 1 to 3-4. Spending on pensions, health and long-term care is expected to increase by 4-8% of the GDP in the coming decades, with total expenditures tripling by 2050.

Current estimates claims there are 1.300.000 dependent persons in Spain and the public spending in 2010 was 5.500 million Euros for care of 650.000 dependents.

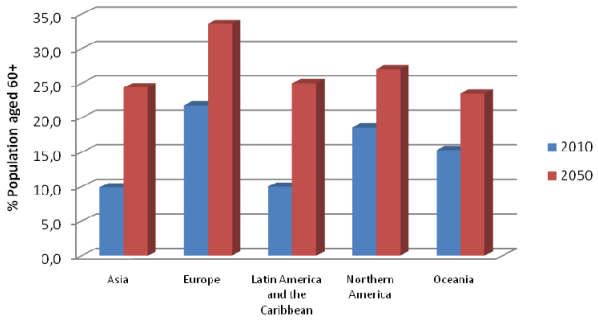

Figure 1. Demographic change according to the foresight of the United Nations, http://esa.un.org/unpd/wpp/index.htm (May 21, 2011)

Although the budget has increased year by year since 2007, it is also true that the current global economic crisis requires a rationalization of social and economic resources more when the public health system has not yet reached the maximum number of dependents entitled to care.

At the other hand, in the last decades there exists an undeniable increase in chronic diseases [5]. Recent data of the European Union reveals the main chronic pathologies are the following ones: diabetes; according to International Diabetes Federation (IDF), the global cost of the diabetes in Europe was approximately of €68.300 million in 2007 and will grow until €80.900 millions in 2025. According to countries, depending on the prevalence and the level of available treatments, the cost in diabetes will be in a rank of 2.5 - 15% of the total of sanitary expenses. The cardiovascular diseases, including all the diseases of the circulatory system, demanded a total cost in Europe in 2006 of €109,000 million (10% of the total of the sanitary cost; in Spain 7%). The indirect costs include €41,000 million loss of productivity and €42,000 million of the cost of the informal cares. All it makes a total of €192,000 millions in 2006. Respiratory diseases. EPOC. The set of the main respiratory diseases (EPOC, asthma, cancer of lung, pneumonia and tuberculosis), is responsible for 20% of all the deaths and generates a cost of €84,000 million in Europe. The EPOC affects in Europe 44 million people, with a prevalence of the 5-10% of population greater than 40 years. According to the

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WHO (World Health Organization), in 2030 will be 3rd. death cause, and first cause of sanitary costs in Europe, due the profiles of the expenses in health and the long time expenses by age groups, and due to their important associate morbidity.

The "Virtual cloud carer" R&D project will try, from the dominion of the information and communications technologies, initiate an approach to the field of the innovation in the integral care to the elder people with chronic diseases, being understood here by integral care, the provision of medical assistance and social support necessary to take care in an ideally correct form to elder people according to their health state.

II. OBJECTIVES

The Virtual Cloud Carer project, through the use of information and communication technologies, intended to cover a range of social and health objectives aimed to improve the quality of life for elder people with chronic diseases. .

A. Technological Oriented Objectives

As Technological oriented objectives we can mention the following:

To design and build a telemonitoring and telecontrol platform for dependent people and their caregivers, in home and outside, the main characteristic of the platform will be an easy and intuitive use, independently of the underlying technology in which it is sustained. A main part of this platform will be a sensing subsystem according to pathologies and/or dependencies, with the possibility of defining thresholds and alarms, by means of connected biomedical and physical sensors to a computer within the dependent's home that measure the different health signs and send this information to cloud for their analysis or visualization for caregivers.

When the person is outside those sensors will be integrated inside an intelligent mobile device connected to Internet by 3G and M2M (machine to machine). Another technological service provided by the platform will be a system for manage physical activity using video streaming and 3D recognition in order to observe the good completion of exercises, this service will be specially recommended for fisioterapeutical rehabilitation.

The project also consider the development of an adaptive communication interface between user and computer, facilitating the understanding of Internet and new technologies to people with a low-tech profile, while encouraging its use by providing a simple and friendly human machine interface.

In the cloud part will be necessary to develop a management platform which main purpose is to distribute the stored information taking in account the user profile, also in this part it is mandatory to define the logic process for alarms and warning generation based in measurements from remote sensors and then communicate dangerous situation to caregivers or medical personnel.

B. Social Oriented Objectives

In this case, the main social objectives lie on the attempt to bridge the gap that prevents the elderly and people with chronic diseases to have a minimal quality of life, permitting people to do daily activities knowing their health status in all moments. Also, we are trying to include elderlies to Internet society, developing simple mechanisms for interaction between technical elements (computer, or special input devices in place of keyboard) and people like, for example, an accessible Web browser to improve usability through the use of alternative hardware to keyboard or voice commands.

C. Healthl Oriented Objectives

Similarly, the "Virtual Cloud Carer" project will provide a range of health-oriented goals that help elderlies to keep active through physical training exercises and, otherwise, assist medical staff in the task of monitoring the treatment of these people from homes. For the case of physical training our idea is to use existing motion tracking technologies based on low cost hardware equipment as for example Microsoft Kinect. This will prevent premature degeneration and improves the senior's mood with functional diversity by increasing the feeling of being useful to society around them.

Development of personalized health services is also a part of the VCC's objectives, such as warning and reminder system for medication adherence through an automatic smart pill dispenser.

The project has also included a module for personalized access to health information in the internet. Some components of this development have been made following MedicalMiner project objectives, that can be found in [8], among which can be highlighted: (1) development of new Techniques of data mining focus on the analysis of personal health information and, (2) design of an intelligent medical information system capable of text and data mining. Specifically, the module implemented for the Virtual Cloud Carer platform provides direct access to selected health information sources such as MedlinePlus, in [9], including automatic text content analysis based on Gazetteer module of General Architecture for Text Engineering software (GATE, [10]) and medical terms covered by the Open Biomedical Annotator (OBA, [11]) and Freebase ([12]).

III. TECHNOLOGICAL PLATFORM´S ARCHITECTURE

Among the initial services of the platform, there are technical difficulties related to the application area. For example, the development of an accessible Web browser must be multimodal and interoperable in order to take into account the needs of all members of the group, which greatly complicates the solution due the diversity of users.

At the other hand, the design of a mobile device for collect bio-sensor information must take in account the diversity of technologies and different communication protocols (USB, IEE, I2C, etc). Is then necessary to develop a proprietary API that deals with this issue and permits send the data from mobile device to Internet.

Another important technical difficulty is to develop a system for 3D recognition for evaluate the rehabilitation exercises without intervention of medical personnel, in this case it is necessary to include information about how well is done the exercises, also the use of common computer applications trough the use of voice commands will permit elderlies connecting to Internet for entertainment and searching for information about their health status. The ability to speak is performed by TTS module (Text to Speech), which will be able to interpret instructions to carry out a phrase, change computer's volume, etc. This module is capable of aloud the name of the icon over which the user is, or alert user of events or errors via voice messages.

For this subsystem the idea is to implements a graphical user interface (GUI) having a similar behaviour to the Windows desktop, but with some innovative characteristics that allow meets the specific 65+ user requirements (size of icons, colours, etc.) including likewise key aspects of advanced user interfaces. An important part of this subsystem will be also a voice commanded Web browser. Fig 1. depicts a high level architecture of the Virtual Cloud Carer components.

The creation of a subsystem for gesture recognition and movement detection is also considered, having in mind the develop of a computer aided physical rehabilitation system in order to assist and augment the physical recovery process of patients with movement disabilities caused by neurological, orthopaedic or rheumatoid problems, by the use of interactive applications and games that monitor the patients' movement and engage them in performing the exercises recommended for recovery.

This is something that many researchers have recently tried to achieve using different devices and sensors for patients' movements detection, like the Wii-mote, but in our case we want to use the Microsoft Kinect, which tracks the

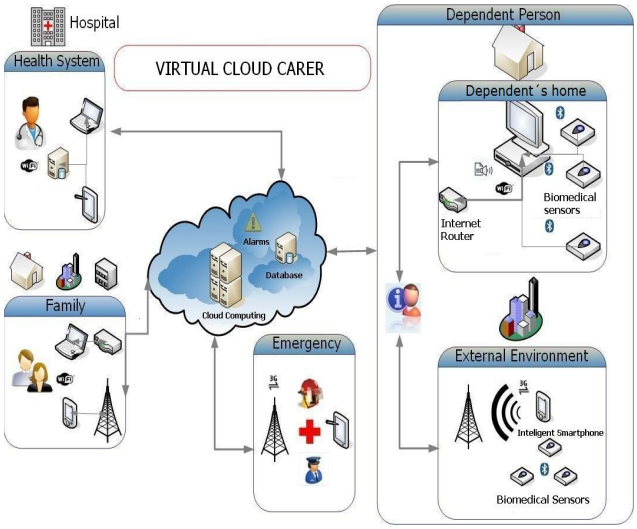

Figure 2. High Level Architecture of Virtual Cloud Carer

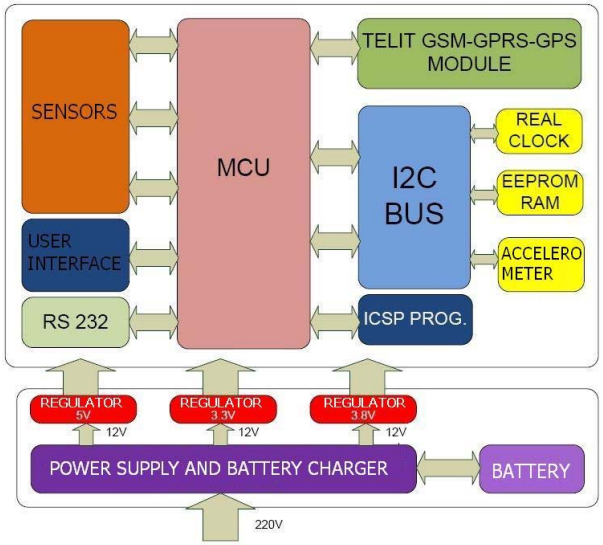

Figure 3. Mobile device architecture

human motion without requiring any devices attached to the body.

About the mobile device our approach is to develop this part around a microcontroller suitable for collecting information from sensors, gps, accelerometers, etc. The device must be capable of transmit data to the Internet trough a 3G or wifi connection via an integrated modem. In the cloud part there will be available a Tcp/IP socket with capabilities for receive and transmit basic information using a special and dedicated protocol.

In the cloud part it is necessary to design and develop a back office system for storing the sensor data and develop the logic processes for generation of alarms based on threshold's measures and integrating this with a messaging system capable of sending information in a user profiles basis and using social networks.

From technological point of view there are a great variety of alternatives on which we have to decide, for example the technological components involved in the design of user interfaces for data presentation through mobile devices, i.e. HTML5.

In the server and cloud part we will use SOA architecture for standardization and because enables and facilitates the development of new applications and services that seamlessly integrate with existing modules without need of an expert knowledge, for voice recognition system will be use SAPI (Microsoft Sound API), for mobile device our intention is using Android as operating system.

In summary the most important technological challenges of the project lies in the design and development of a intelligent mobile device capable of integrating a variety of biosensors as for example oximetry sensors, glucose and others, including accelerometers and GPS for localization. At the cloud part our efforts will be dedicated to design and

to develop a platform for collect information and process it for generate alarms and directions for elderly's caregivers or medical personnel and the exercises dedicated to the computer aided physical rehabilitation, the other subsystems mentioned above are also important but at this stage of the project these are not a priority.

IV. EXPECTED RESULTS

The VCC Project (Virtual Cloud Carer) has as goal the design and developing of a technological platform allowing elder people and persons with chronic diseases to increase their quality of life. In this paper we have focused on the preliminary ideas around the development of an intelligent mobile device for managing the information provided by sensors and the infrastructure at the cloud part, also we present some details about a health information service for elders integrated as a part of the technological platform.

As mentioned above, from the point of view of development, the project's expected results are:

- A hardware interface device adaptable to all seniors and people with disabilities enabling the interaction with computer or television.
- A mobile device capable of collecting information from sensors and transmit these data to internet.
- The development of services including an adaptable Web browser that allows access for elders and disabled people to the Internet.
- A subsystem for gesture recognition and movement detection for physical rehabilitation in order to assist and augment the physical recovery process of elderlies with movement disabilities
- An analysis of business opportunities and business requirements (identifying their strengths and weaknesses) for the successful commercialization of the project results.

During the running of Virtual Cloud Carer project two case studies/scenarios will be implemented to demonstrate the functionality of the framework developed. One dealing with rehabilitation at home, based on gesture recognition, internet access through special input devices and using voice commanded common computer applications, while another scenario will be developed and evaluated in a care centre with elders and chronics bringing the mobile device and sensors. The scenarios will have real participation of end users to validate the technological advances.

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