

## Elder Care Modular Solution

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**Abstract—** The Elder Care solution has two primary goals: monitoring vital signs, sending alerts to family and specialized help and provide a social network in order to wrap all older population to avoid social isolation [1][2].

In this paper we will show the methodology used to obtain Elder Care’s architecture and point some guidelines to our present work: Elder Care’s implementation.

**Keywords:** health monitoring, wireless sensors networks, body area network.

### I. INTRODUCTION

It is a fact that population is getting older [3] [4]. Following that evidence, and given the poor health that usually follows, together with the lack of time of working family members to assist elderly, justifies the need for continuous healthcare service.

Thus, fewer families manage to provide proper care to their aged ones, either by assisting simple daily home tasks or monitoring elder’ health and social interaction with the human being as an individual [5].

The problems mentioned could be dealt through permanent examination of the elder and the existence of a device capable of minimizing elder’s isolation and gathering the knowledge accumulated over the years.

Concerning the material aspect, the outbreak of wireless communication enabled remote people’ monitoring and provided a 24-hour surveillance (without jeopardizing personal features) with low costs and accurate information on heart beat, blood pressure or fall detection [6] [7].

Body Area Networks (BAN) were created specifically to monitor and record patients’ vital signs in a continuous way, providing a more complete health status observation and increasingly accurate medical diagnoses [8] [9].

Concerning the social and psychological elements, the Information and Communication Technologies (ICT) enabled the appearance of systems and infrastructures that allows: to increase the quality of life (having in consideration physical limitations, for instance, mobility); to use the knowledge and experience accumulated by older people; to provide the creation of new services that will meet this community’s expectations, for example in communication (diminishing loneliness), health monitoring and supporting active participation in the society.

Given the previously exposed concern, as well as the emerging of the BAN and dissemination of the ICT, there are some solutions presented by companies, academic assignments and European projects in the scope of monitoring health parameters. These solutions diverge both in the technology and the sensors used. While some choose to place autonomous devices [10], others select solutions that depend on the patient’s interaction [11]. Solutions with sensors within clothes exist [12], while others prefer sensors implanted in the patient [13] [14]. There are also major software companies turning to health monitoring area, such as Microsoft [15] and Google [16].

The existing project focuses essentially in the physical well-being of aged people. The Elder Care proposes a modular solution containing some aspects of physical well-being widening its range to the social and emotional component.

Elder Care can be defined by the following guidelines:

- Combine technologies such as wireless sensor networks and RFID;
- Plan elder fall detection;
- Monitor involving a physical component: gas, fire and floorings;
- Introduce quality of service and security in communication networks;
- Develop a “virtual space” of conviviality, learning and attainment of services;
- Apply to exceed keyboard, mouse and system error messages obstacles, by developing a new interface approach;
- Propose a simple and intuitive interface based on elder’s physical restrictions;
- Create a database that gather the collected information and that can communicate with other health data sources;
- Use artificial intelligence mechanisms to identify changes in elder’s routines that can point to risky situations.

### II. INTERVIEWS

In order to achieve a solution that meets final users’ expectations, we followed a qualitative research with semi

structured interviews in order to obtain the requirements necessary for the proposed modular solution [17] [18] [19].

Six interviews were made to agents familiar with the problem: a hospital director, a social security and elder home care director, a doctor, an older person and two nurses. This sample allowed us to have a more accurate vision of final users' needs in order to present an architecture sketch.

#### A. Hospital Director

The interviewed hospital director belongs to an Integrated Care Coordination Unit.

He mentioned that the elderly do not like leaving their residence or having a stranger at home looking after them; especially when bound has been made.

Even though they are being cared for at home, there are still periods, mainly at night, where seniors may be alone. The apprehension shown by the hospital director on this matter is not just about lack of monitoring, but also due to the loneliness elders feel. There is also a main concern with geographic isolation that affects many elders in our country, limiting continuous support.

The hospital director pointed to the urgent need to prevent social isolation.

As a response to these concerns, Elder Care's includes continuous monitoring vital signs and a virtual leisure room.

#### B. Social security and elder home care director

The interviewed social security and elder home care director works in private home care with 70 seniors.

She usually takes some of them to a city council program that consists in attracting elder people to an internet space in a weekly basis.

In the course of this contact with elders and the analysis of how they interact with technology, the social security and elderly home care director pointed as their major difficulties the ability to work with the keyboard and mouse. However, that barrier is overcome by their huge curiosity and enormous interest in searching any subject on the web.

In order to prevail over this obstacle, the proceedings involved in Elder Care are simple and repetitive, bearing in mind elder's feeble skills and memorizing difficulties. Interfaces with touch screen devices are replacing standard keyboards and mouse.

#### C. Doctor

The interviewed doctor has been a doctor in a public health unit for more than 20 years.

He mentioned as one of his major concerns the fact that several of his elder patients that live alone have already had a stroke or had fallen and remained alone for several hours before neighbors or family missed them. After these episodes, family members (usually descendants) become extremely nervous and contact their parents frequently, in order to check that everything is ok. This procedure affects the whole family in their daily tasks.

To avoid the problems mentioned above, Elder Care supervise elder people, promoting increased safety feelings both on seniors and their relatives.

#### D. Elder

The interviewed elder is a 74 year old female widow who lives by herself at home. She retired 3 years ago and used to be a university language teacher.

At the beginning of her professional activity, all work was based on paper. With the rise in the use of technologies, computers progressively substituted paper proceedings. Her main fear is to damage software or hardware and be without the equipment during its repair. She gets anxious whenever the computer responds differently from what she is expecting. She referred the use of automatisms, routines and mnemonics in order to do her work properly.

When asked if she considers it a problem that doctors have access to her medical records from a continuous monitoring, she does not consider it an issue. As a matter of fact, she thinks that it is beneficial that doctors can access all her information in order to be more precise in their analysis. In her opinion, the access of medical staff to a clearer diagnosis gives her a sense of security, as well as having continuous monitoring than can give a real time answer when an abnormality occurs.

As a conclusion from this interview, it must be highlighted the relevance of a simple interface in Elder Care. We can also conclude that it is essential to have training courses to involve Elder Care seniors in their daily routines.

#### E. Nurse 1

The interviewed nurse has been practicing for the last 14 years.

According to her opinion, and following her experience, the elderly are not likely to use technology. After some years watching older people struggling over cell phones, there are still some of her patients who complain about their inability to use them. Many of her patients can't even read, so they have to memorize proceedings to be able to call 2 or 3 people and to ask for help if they need other functionalities from the cell phone.

Nevertheless, in her opinion, monitoring vital signs is an advantage, as well as having some device that allows elders to communicate, because isolation is one of their critical problems.

To circumvent the problem of interaction between elders and technology, Elder Care is designed to have a simple touch screen device with configurable options. It can show only images or text and images associated with sound. The application on multimedia device will also have a small number of options in order to allow an easy memorization.

#### F. Nurse 2

The interviewed psychiatric nurse worked with the elderly in a hospital emergency room and, during 3 years, in

an elder care home. At the present date he is a university teacher.

His greatest concern is the isolation experienced by many older people. He observed that their social isolation is not a small town phenomenon where people are often geographically isolated, but also in big cities where they do not feel safe on the streets and start to spend more time at home.

He thinks that monitoring elders is a very important issue because it increases their welfare. As a nurse, he enumerated the following items as the most important to watch in an elder population: blood pressure, heart rate, temperature, respiratory rate and blood glucose. He also referred that it was crucial to have elders' GPS coordinates to archive their location. That would avoid problems that occur frequently when elder people work alone in agricultural fields, frequently using tractors or other agricultural tools.

Adding an idea to the virtual leisure room that could increase welfare of the elders, he mentioned their access to services such as home small-repairs, on-line shopping and other services that could improve their lifestyle quality. Elder population displays many needs and is often faced with the absence of a global and easy access solution.

As a response for solitude, Elder Care has a virtual leisure room. The idea of having services request was embedded in the virtual leisure room.

### G. Review

As the interviews were being conducted, a sketch of the architecture was elaborated. At the end of each interview, this sketch was shown so that more targeted reviews could be made.

To acknowledge our interviewed major concerns, we used Leximancer software. It is indicated in Leximancer software webpage that "through a rigorous scientific process, Leximancer drills into textual data: documents... and extracts the main concepts, themes and causal relationships to provide the information needed to make critical decisions" [20]. Leximancer was therefore, applied to the interviews made, in order to provide a schematic relationship between concepts and terms spoken during the interview. This allows us to have an idea of what are the most important terms to the persons interviewed.

In Figure 1, we can observe that the more spoken word during the interviews was "Elder". We can also conclude that social aspects and health are very relevant to all the interviewed, while technological issues are referred but not necessarily connected to elders.

Figure 1 also gives us the perception that security and social matters are the more relevant aspects, even more important than health. Therefore we were able to notice the extreme importance of providing a solution that covers social problems.

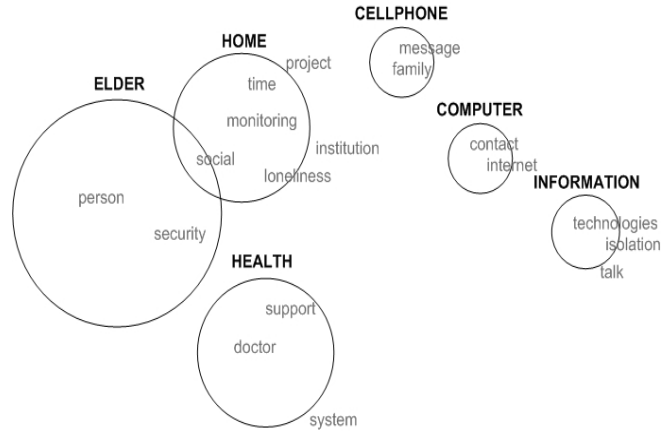


Figure 1 - Leximancer concept map

All the interviewed expressed as their first and main concern, the loneliness experienced by elderly population overruled by the existence of the virtual leisure room.

Another feature following the whole system, and identified as a very important added value, was the sense of security that Elder Care provided due to alerts management.

Some interviews also revealed requirements that were not previously planned and the reformulation of some of the already existing, such as:

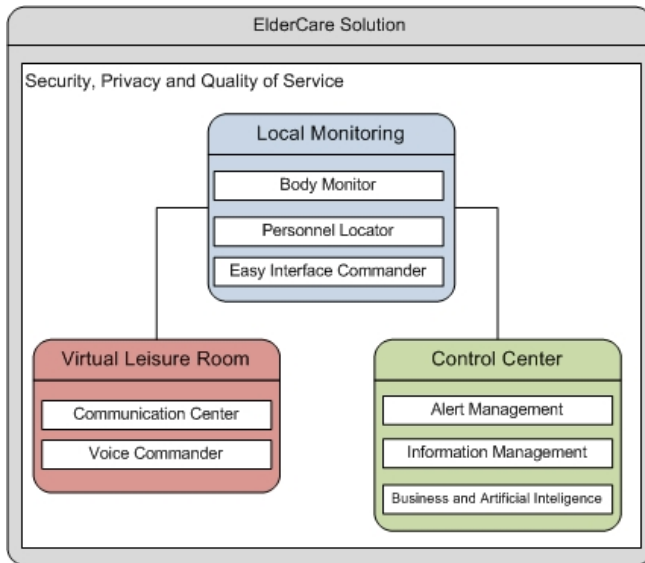
- the inclusion of a blog with social events occurring around the user's residence;
- a device worn by the elderly that obtains GPS coordinates;
- the most relevant parameters to be measured are blood pressure, heart rate, temperature, respiratory rate and glycemia;

### III. PROPOSED SOLUTION

The development of a high-level architecture of the system led to a modular concept.

Elder Care is divided in several modules, as shown in Figure 2:

- Local Monitoring:
  - Body Monitor
  - Personnel Locator
  - Easy Interface Commander
- Virtual Leisure Room:
  - Communication Center
  - Voice Commander
- Control Center:
  - Alert Management
  - Information Management
  - Business and Artificial Intelligence
- Security, Privacy and Quality of Service



**Figure 2 - Elder Care Solution**

#### A. *Body Monitor*

Body monitor comprises the development, programming and deployment of a BAN, which acquires vital signs from an elder's body, in a non-invasive way. This BAN is very tied to the Communication Center system because BAN sends data gathered from the elder's body to the communication center but can also receive commands from it.

Being the core of the system, BAN must be scalable because the sensed variables and data resolution may change from day to day.

Another important feature to be implemented in the BAN software is the no need (or almost none) of human intervention either for configuration or parameterization. This means that some sort of autonomous computing features must also be implemented on the sensor network.

BAN will include a gateway to serve as bridge to the existing network (fixed infrastructure at home and cell phone outside). When the elder is indoors, the gateway communicates with the existing LAN. If the elder goes out, the gateway must be capable to use the elder's cell phone to reach the communication center.

BAN will gather blood pressure, heart rate, respiratory rate, temperature and detect the fall event.

#### B. *Personnel Locator*

Other important information to be collected is the elder's location. This data could be achieved by using sensor nodes (using its signal strength + ultra-sound sensors) if high precision is a requirement or using RFIDs, which offers low precision but is a cheaper solution. This is still an open topic that must be deeply investigated. When outside, special localization is grouped by using a sensor node (on the BAN) equipped with a GPS system.

#### C. *Easy Interface Commander*

The intention of Easy Interface Commander is to study the interface provided to the elder to allow their interaction with the virtual leisure room. The focus must be on non-intrusive and intuitive interfaces that take into account the physical and mental limitations of some of its users.

The virtual leisure room promotes a social relationship between all the elders from Elder Care solution in order to prevent social isolation. Easy Interface Commander is going to be conceived to allow elders with different levels of literacy and motor capabilities to socialize and to enable the connection with the virtual leisure room.

#### D. *Communication Center*

Virtual leisure room will be divided in areas such as: communication, knowledge record, hobbies, education and culture and service requests.

Communication will appear in order to allow Elder Care users to interact with each other and with their family and friends by wrapping applications that are already in use, such as Google talk, messenger, blogs and other social web applications.

#### E. *Voice Commander*

This task will start by testing the limits of existing voice and speech recognition engines applied to the problem at hand. Based on these initial studies, the recognition algorithm will be adapted to improve the recognition rate under the defined extreme conditions (to be able to adapt the recognition algorithm the project will favor the use of open-source projects, such as Sphinx).

Besides tuning the algorithm and adjusting the training of the recognition engine, tests will also be made to develop a reliable voice commander that could work different microphones configurations.

#### F. *Alert Management*

One of the crucial points of the system is the alert management.

In alert management module, we are going to have an information repository containing elder's information, such as medical historical records (including vital parameters detailed data), routines (like schedules of usual time spent outside the residence).

Whenever information is received in alert management, an automatic analysis process must be completed, comparing received data with historical records. If an abnormality is detected, an SMS, via GSM, is sent to a list of configurable elder contacts. According to the abnormality, specialized help will be notified.

After help support, the procedures are archived. Also, it will be indicated if the emergency was real or only false

alarm. This method will allow the system to learn what the regular values are for each person.

### G. Information Management

The main steps of this task are:

- Identify the relevant information to collect (personal relevant information of the elder, medical information, from local monitoring to support control centre operations, for the leisure room).
- Design the solution to meet the constraints of robustness, scalability, interoperability and real-time operation.
- Design a contact centre solution to support control centre operations: communications centre and specific support database.
- Design human interaction for the contact centre solution considering the constraints of the elder: lack of mobility, computer interaction knowledge, and reduce error in the communication and a Citizen Relationship Management (CRM) perspective.
- Design interfaces for the family, the medical doctor and the social assistant.
- Expand the database system.
- Develop interface with other existing systems using the Health Level 7 (HL7) framework and standards.
- Develop the contact centre solution.
- Integration and production tests.

### H. Security, Privacy and Quality of Service

Security, Privacy and Quality of Service module is a cross-system assignment, aiming to contribute to several tasks of this project, mainly to the Local Monitoring and Control Center tasks. Computer and network security aim to provide confidentiality, data integrity, and service availability. Confidentiality prevents unauthorized third parties from accessing sensitive data, and data integrity aims to protect information against in-transit modifications and replay attacks. Availability ensures that authorized parties can access data, services, or other computer and network resources when requested. Denial of Service (DoS) attacks target availability by preventing communication between network devices or avoiding a single device from sending traffic.

The first main objective of this task is to guarantee the confidentiality and integrity of the collected data when in transit, inside BAN, between the BAN gateway and the Local Monitoring and between the Local Monitoring and the Control Center. This objective can be achieved with encryption techniques. However, the conventional encryption techniques could not be used because of the low computational resources of the network nodes. A set of symmetric encryption algorithms and techniques must be

evaluated in the project scenarios and an adequate and scalable solution should be proposed.

The second main objective of this task is to protect the BAN nodes against DoS attacks. The work will be mainly focused on the evaluation of several mechanisms to avoid DoS attacks on the five layers of the TCP/IP stack, able to protect the system against this kind of attacks. This issue is of primordial importance because a successful QoS attack could avoid critical information to be known by the medical staff, resulting into dangerous medical situations.

The third objective of this task aims to control the access to sensitive information stored in the central database and the transmission of alerts. This objective is concerned with the privacy of sensitive medical information, stored in the Control Center database, and of the alerts to the medical staff. A deep study of the privacy policies should be made, taking into special attention the sensitivity of the information involved. These policies, aimed to enforce access control, should be dynamic and context-aware, being dynamically altered based on context. Traditional role-based access control systems, which make access authorization decisions based on users' and groups' static roles and policies, is not flexible enough to enforce this objective. A privacy protection framework that is dynamically adjustable to residents' context should be proposed in order to allow data access authorization to be evaluated at runtime and to enable the adaptation to residents' health emergencies.

In addition to open questions like security and privacy factors, QoS issues are also of major concern. The last but not the least relevant purpose is devoted to QoS in Wireless BAN applications, described as being very sensitive. A special attention must be taken regarding QoS issues, in particular the Control Center and Local Monitoring subsystems, because a degradation of the QoS will put human lives at risk. This question still assumes a vital importance if we consider the complexity involved in the quality of the service on wireless networks.

### I. Business and Artificial Intelligence

Business intelligence techniques will be applied to data collection, organization and normalization for analytic oriented purposes.

Personal data such location, biometric, vital data, and so on, will be analyzed, in addition and combined with neighborhood sensed data from home sensors, and wider context data such as weather conditions, among others.

Prediction, classification and decision support techniques will be applied for elder personalized assistance and guidance, for physical and health risk assessment, for personal behavior monitoring and classification.

Application data dissemination and routing, managed using knowledge-based networking models will be used to dynamically forward filter data. Application data is to be forwarded according to knowledge-based representation and

reasoning techniques, both for regular and urgent events and pre-defined or inferred situations.

Communication channels, individuals or groups' destinations, systems and inter-systems cooperation self-configuring, self-optimizing, self-adapting and self-protecting features are to be adopted in order to provide safety, fault tolerance and dynamic optimization.

The prototype will rely on simulated data generation with healthcare domain experts' help, for training, testing and system validation purposes.

CRISP-DM (Cross-Industry Standard Process for Data Mining) methodology is to be followed for the guidance of all intelligence data analysis and modeling. Open source development environments and frameworks, tools and artifacts will be preferred, whenever suitable, for model specification, documentation, implementation, testing, etc.

#### IV. CONCLUSIONS AND FUTURE WORK

Considering an elder population and the lack of a proper support from family members, in addition with the fact that new technologies are emerging (such as wireless sensor networks), many projects are being developed in order to seek a solution to improve the elders' quality of life. The study of the solutions found led us observe some deficiencies. They do not interact with national health system, which means that all the information obtained through monitoring is still not accessed directly by the patients' doctors and therefore the potential for providing detailed information that allow more accurate diagnosis and prevent illnesses is underestimated. Many solutions are generalist, not including a target population and their special needs. For example, in elders' case, interfaces must be simplified and all the tasks have to be intuitive without huge memorizing processes being necessary. There are a wide number of solutions concerned about the physical part but that neglect the psychological side. Most solutions do not provide a global response and thus do not allow the senior population to have only one centralized and simplified solution. Since elder people must interact with different products and solutions in order to have a physical monitoring and a social support, the complexity is considerably and thus they abandon those solutions.

Elder Care stands out from all other solutions by expanding its purpose to a social level, focusing not just on the physical well-being of elderly people, but also on the social issues and on a response to the insufficiencies presented above.

We followed a qualitative research with semi structured interviews in order to obtain the requirements necessary to the Elder Care's architecture. Six interviews were conducted (medical doctor, nurses, elder, hospital director and social security and elder home care director) in order to ascertain the intervenient main concerns. We were able to conclude

they all feel the same distresses: lack of security and social isolation. These concerns guided our work to achieve a solution that encloses physical and psychological well-being. The interviews led us to a high level architecture and then, to a modular concept.

Presently, we are developing prototypes for Body Monitor and Personnel Locater modules. Additionally, we are progressing on Easy Interface Commander module. Studies on the way of developing easy interfaces for elder population and tests of the features on real subjects are also being carried on.

#### REFERENCES

- [1] Marcelino, I., Barroso, J., Bulas Cruz, J., Pereira, A., Elder Care Architecture, Proceedings of the 2008 Third International Conference on Systems and Networks Communications, IEEE Computer Society, 2008.
- [2] Marcelino, I., Remote monitoring and social isolation prevention structured system for elders, University of Trás-os-Montes e Alto Douro, Master degree thesis, 2009.
- [3] United Nations, Department of Economics and Social Affairs, Population Division, World Population Prospects – The 2006 Revision, Highlights, 2007.
- [4] Barros, P., Simões, J., Portugal Health system review, European, 2007.
- [5] Varchney, U., Pervasive Healthcare and Wireless Health Monitoring, Springer Science, 2007.
- [6] Jovanov, E., Milenkovic, A., Otto, C., Groen, P., A wireless body area network of intelligent motion sensors for computer assisted physical rehabilitation, BioMed, 2005.
- [7] Stankovic, J., Cao, Q., Doan, T., Fang, L., He, Z., Kiran, R., Lin, S., Son, S., Stoleru, R., Wood, A., Wireless Sensor Networks for In-Home Healthcare: Potential and Challenges, HCMDSS, 2005.
- [8] IEEE 802.15 WPAN Task Group 6 Body Area Networks, <http://ieee802.org/15/pub/TG6.html>, visited at January 2009.
- [9] Li, H., Kohno, R., Introduction of SG-BAN in IEEE 802.15 With Related Discussion, IEEE Xplore, 2007.
- [10] SDT Wireless Vital Signs Platform, <http://www.stnd.com/>, visited at November 2008.
- [11] Health Hero Network, <https://www.healthhero.com/>, visited at Mars 2008.
- [12] Biotex, <http://www.biotex-eu.com/>, visited at Mars 2008.
- [13] ISSYS, <http://www.mems-issys.com/implantable.shtml>, visited at Mars 2008.
- [14] Cardiomems, <http://www.cardiomems.com/>, visited at Mars 2008.
- [15] Microsoft Health Vault, <http://www.healthvault.com>, visited at September 2008.
- [16] Google Health, <https://www.google.com/health>, visited at September 2008.
- [17] Myers M. (1997) Qualitative Research in Information Systems. MISQ Discovery, 1997.
- [18] Myers M., Newman M., The qualitative interview in IS research: Examining the craft, Elsevier, 2007.
- [19] Rijo R., Gonçalves R., Varajão J., "Factores chave dos projectos de sistemas de informação de contact centers: research design, Edições UFP - Novas Perspectivas em Sistemas e Tecnologias de Informação, 2008.
- [20] Leximancer, <http://www.leximancer.com/product.html>, visited at Mars 2008.