Smart Adaptable System for Older Adults' Daily Life Activities Management - The ABLE Platform

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Abstract— **In this paper we propose a system (ABLE) that will act as the main platform for a number of low-cost, mature technologies that will be integrated in order to create a dynamically adaptive Daily Life Activities Management environment in order to facilitate the everyday life of senior (but not exclusively) citizens at home. While the main target group of ABLE's users is the ageing population its use can be extended to all people that are vulnerable or atypical in body, intellect or emotions and are categorized by society as disabled. The classes of assistive products that are well defined in the international standard, ISO9999 such as assistive products for personal medical treatment, personal care and protection, communication, information and reaction and for personal mobility, will be easily incorporated in our proposed platform. Furthermore, our platform could integrate and implement the above classes under several service models that will be analyzed further.**

I. Introduction

The field of home automation is expanding rapidly as electronic technologies converge. The home network encompasses communications, entertainment, security, convenience, and information systems. The ABLE platform development addresses the improvement of the living-at-home quality of elderly individuals. Aging is a global trend that will continue for future generations. Currently, 19 of the world's 20 "oldest" countries - those with the largest percentage of elderly people (65 or older) - are in Europe. In Italy, the world's oldest country by these standards, over 19 percent of the population is elderly. This figure is expected to reach 28 percent by 2030. In Germany, life expectancy is expected to reach 90 by 2050. Ambient assisted living and the improvement of the living-at-home quality for the elderly population is not only a European but a global issue. This issue however pinpoints the capacity for a European wide impact of our proposed platform. Through ABLE, we aim to deliver a system that can prolong the stay of elderly citizens at their own home. This will be achieved by integrating already available technologies and solutions into a smart-home environment so that seniors can enjoy automated care and assistance at their own premises. Our proposed platform will provide "horizontal" services at a pan-European level. The horizontality of the solution will ensure the capability of easy adaptation so as to meet different societal and cultural needs as well as economic restrictions that may differ across Europe.

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II. The Able Platform

A. Researched Service Models - ABLE through **Localisation Assistance at Home**, will allow optimization of the user's movement within the home. By using the local information management service the user will make the least possible movements required to accomplish a specific task. The following technologies will be implemented:

1. Real time localization services with Wi-Fi tags. Tags will be placed on commonly misplaced items such as mobile phone, glasses, car and home keys. Location of these items will be displayed on the central information monitor overlaid on a floor plan of the house.
2. An unobtrusive portable electronic device (described below).

Likewise, the **Local information management** service, will make sure that the user is aware of all possible "states" of the technologies and or services that are integrated in the platform. The following technologies are envisaged:

- A central information monitor - this monitor will serve as the main information point of our platform. It will be situated close to the entrance of the home so that the user will have easy and profound access. This can be an active mirror or smart surface. This monitor will alert the user in all cases and also present him/her with relevant information.
- Call centre integration - a dedicated call centre will be receiving alert data and will be able to make calls to the user's home in case of emergency.
- General Memory Aids can either be part of the health kiosk or fall under the general communication gateway of the house (this can be the user's computer). An electronic organizer for everyday information management and computer applications especially designed for users with cognitive impairments will be used for training.

Moreover, under the **Telemedical Assistance at Home** service, a Health Kiosk will gather, store and transmit health information using digital technologies. This health kiosk, which will be the main health measurement station of our integrated system, will include amongst other well-known features (vital sign measurements), a drug reminder system. Although aimed for users with memory impairment a medicine reminder system like the MD2 can increase adherence, eliminate drug misuse and treatment failure.

Recent advances in ICT for ageing well (and active ageing) have focused on the development and validation of technologies, tools, techniques and overall solutions for the

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effective management of falls. Through the **Safety@Home** service the following technologies will be integrated:

• Floor sensors in the bathroom and kitchen floors (where most fatal falls occur) for fault detection. The system will be able to raise immediate alerts if a fall occurs in either room.

• PtZ cameras: all rooms will be fitted with inactive cameras that have a point-to-zoom facility. A camera will be activated once it receives the alert call from the fall detection sensors and the sensor on the portable device.

• An unobtrusive portable electronic device (the size of a digital camera) fitted with fall detection accelerometers and a panic button. This device will be able to communicate via Wi-Fi with the home's central information hub and also include a sensor that will attract the PtZ cameras upon fall detection.

• Sleep Management Hypnogram management: ABLE will contain a sleep architecture monitoring system in order to assist the user maintain his circadian rhythm. The SAMS will be able to detect Seasonal Affective Disorder and/or Delayed Sleep Phase Syndrome and alert the call center accordingly. ABLE will also include a sleep apnea monitoring system

5. Smart Engine: Everything gets smart is a common conception in the research field of Pervasive Computing. The **Smart Engine** service which is proposed in our platform will detect any aberrant behaviour as early as possible in order to trigger an alert or activate another appropriate process as quickly as possible. A smart home is a residential setting equipped with a set of advanced electronics, sensors and automated devices specifically designed for care delivery, remote monitoring, early detection of problems or emergency cases and promotion of residential safety and quality of life.

ABLE aims to target elderly users that don't have an informal carer living close-by. It aims to extend these users' independence so that they are sustainable while living alone. These users may or may not have a designated formal carer but our platform will help them be more active and happy in their homes. It will be mostly appreciated by the "old" and "old-old" groups.

It is easily understood that the plethora of sensors fitted throughout the home does not constitute an integrated solution until the information received is processed and run through a rules engine that produces valuable outputs and an overall integration plan has been executed.

Finally our platform aims at increasing the acceptance level of assistive technology from Reluctant to Grateful or even better Internal [1]

B. An example Scenario

Olivia is 44 years old and had a car accident a few years ago. She lives alone and in order to complete her daily tasks at home requires assistance since her mobility is restrained. The ABLE application will allow her to ensure her independency in the house by optimizing her movement as far as the location of several objects in the house are concerned. It will be able to remind her drug treatment, keep track of her daily activity and organize her tasks or even alert her to situations like "oven is still on". Likewise, the embedded floor sensors of the ABLE technology, will allow prevention of any fall, minimizing the risk for further injuries. Last but not least this smart system will be able to adapt its services though customization, to Olivia's needs, leading to a more comfortable life

C. The Aimed Service Models ABLE will allow optimisation of the user's movement within the home through **Mobility Assistance at home** service. By using the local information management service the user will make the less possible movements required to accomplish a specific task. The main innovation of this service is the reduction of physical effort from the end user to the minimum. The technology behind it is available today (at least in terms of hardware, sensors, etc.) and the requirement is the training of the system within a specific space (user's home) by modelling the resident's activity based on their past movements (LeZi algorithm [2], Hidden Markov Models). In order to gather further data on movements in the house, IR sensors are installed above each room entrance and at foot level in the kitchen and corridor. Two RFID systems are used to identify the residents, one active and the other passive. The former uses 315 MHz waves, while the latter operates in the 2.45 GHz band. Active scanners are located above the ceiling of each room, and detect RFID tags whenever a subject enters. [18, 19] Passive system antennas are embedded inside the walls around each room entrance, and read out data on the tag when a person passes through.

In addition, the **Local information management** service will make sure that the user is aware of all possible "states" of the technologies and or services that participate in ABLE. All relevant information will be displayed in the main screen close to the home exit. For example there will be a notification when the user moves towards the exit having forgotten his phone at home. The sensing modules of the room record the states of the floor, bed, table and switches. The combination of these data is defined as the "room state". An algorithm named "summarization" will also be developed, which will segment the accumulated sensor data at points where the outputs change drastically. The segments will be matched with and assigned to "room states". The algorithm will also try to eliminate redundant states that have changed only slightly. The system will include switch sensors on a number of appliances, in addition to the table, chair and bed. These sensors are sufficient to detect whether a human is standing or sleeping, to detect the position of their hands on the table, and to detect the positions of objects on the table. The freezer, refrigerator, microwave, toaster, windows, and chest of drawers are all equipped with switch sensors to detect whether their doors are open or closed. An informative, adapted to the specific user group, User Interface, will be available presenting vital information to user.

The Health Kiosk will gather, store and transmit health information using digital technologies via the **Telemedical assistance at home** service model. It will use the available sensors (blood pressure, temperature, microphone, etc.) that capture/record vital signs (pulse, respiration, movement) and analyses it through Fuzzy logic. In case alerts are raised (based on the Smart Engine) the Safety@Home Service (through the Alert Management feature) will enable the intervention of the call centre and triage operations will be initiated

The **Safety@Home** service model will include Fall prevention, Alert Management and Intrusion Detection. Recent advances in ICT for ageing well (and active ageing) have focused on the development and validation of technologies, tools, techniques and overall solutions for the effective management of falls. The respective solutions include sensors for the timely detection of falls, pervasive applications for triggering alarms, actuators for improving the surrounding environment (e.g., lighting conditions. Intrusion Detection systems (cost/value ratio considering) will be integrated in the ABLE platform.

The **Smart Engine** will apply rules that will create a holistic systemic approach to home safety. Everything gets smart is a common conception in the research field of Pervasive Computing. A lot of products and devices that we use in daily life are already smart. Likewise our living spaces become smarter day by day. Smart homes and environments are nowadays no longer science fiction. One aim of Smart Environments and Product is to enhance the comfort of the occupant and the user respectively. All these comforts can offer an essential benefit for people with disabilities or elderly persons. Such equipped environments have the ability to compensate some disabilities of the occupant. They can simplify their daily lives and reduce their dependency on other persons. They can use all the provided functionality of the environment themselves, reinforce their independence and personal freedom and can therefore remain longer in their usual surroundings. Therefore Ambient and Assisted Living is one important field of application for Smart Homes allowing for tailored interventions. These systems have the potential to support aging and improve quality of life and decision-making for people in need, disabled and aging people. The well-being Domain includes a range of factors like health, fitness, depressive symptoms and cognitive functioning. The proposed framework will observe activities and behaviours, which are related to these factors, and it will dynamically generate rules and actuate processes in order to dilute, normalize or fortify the various well-being facets.

In order to create a comfortable environment for the user, home automations relative to the environmental control will be placed in the home and integrated to the ABLE platform creating the **Home Environment Controls.** Last but not least, some basic **Home Entertainment** integration will be offered (rule-based TV control, etc.)

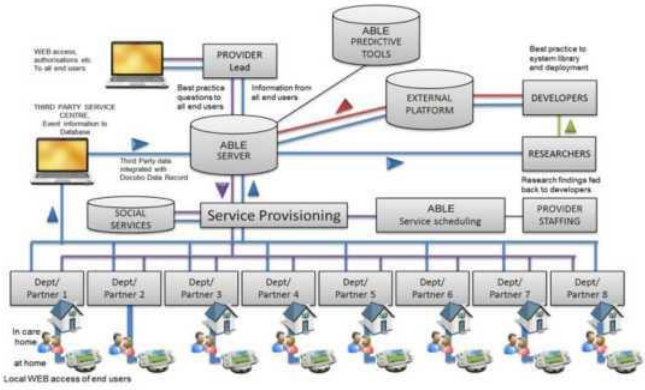

Fig 1 ABLE Architecture

The occurrence of many pilots across different EU countries will help the ethical adjustment of the platform in order to ensure that legal and societal issues are addressed. First of all, any legal, reglementary and ethical adaptations for each European country involved will be assessed during the pilot phase and any imposed change to the product will be incorporated. In addition, due to the spread of the pilots at different European countries the adaptability and cultural adaptation (language, ergonomics etc.) will be addressed such as the ABLE system could be widely used across Europe. At this point, we should also underline that the platform will be adaptable based on the needs and cost limitations of the consumer. Although a wide range of services will be available through the platform, the user will have the chance to accommodate less services (if desired) in the platform based on his needs. This functionality, will allow citizens with different needs or economical restrictions to afford the product. Finally, we should underline that all elements of the proposed system and ecosystem do take into account from their early design phase, the fact that the European market is targeted with all its disparities and cultural heterogeneity. Nevertheless, the scalability and generic and standards-based approach allows to envisage all necessary adaptation other national or local's implementation requirements.

Exploitation will be possible to evolve in parallel with the technical work and it will become more intense while approaching the finalisation of the product. In this way the final product will be considered from a variety of different perspectives. We will be able to understand in more detail what we have to offer and reveal the business added value of such service in the context of several countries. When the exploitation phase is running, factors such as maturity, current trends and users' expectations will be addressed across the platform's life time. In fact the end user organisations piloting the service will serve as feedback providers on the feasibility of the technical approach as well as to provide input concerning the marketability of the product in each country. Through such organisations we also expect to identify potential European-wide actors that will provide a clear idea about the market

conditions in which the ABLE platform will be commercialised such that they could be taken into consideration. In addition, products and concepts to be included will be addressed against cultural protocols and aim to incorporate them. Any interoperability and standardisation issues that could contribute to the creation of a generic and scalable product to be adjustable in the needs of each different user will be attempted.

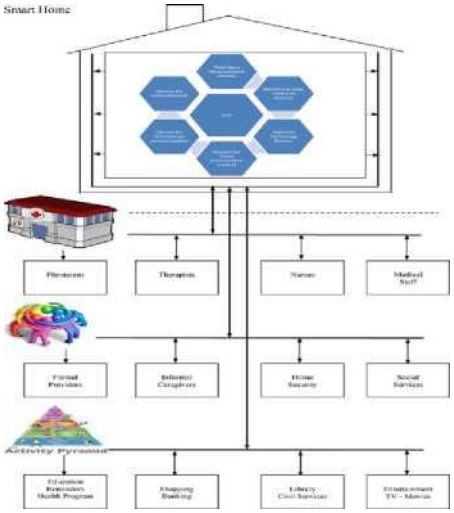

Fig 2. ABLE Ecosystem

IV. Conclusion

Interest in intelligent assistive technology for older adults is growing rapidly. Maintaining functional independence is a high priority for many older adults. Patient data monitoring is a key issue for health and disease management. [12] For these citizens, often, staying in their own homes is key to such independence. Advances in information communications technology and related computational power are providing a wide array of systems and related services that form the basis of smart home technologies to support the health, safety and independence of older adults. While these technologies offer significant benefits to older people and their families, they are also transforming older adults into lead adopters of a new 24/7 lifestyle of being monitored, managed, and, at times, motivated, to maintain their health and wellness. Computer technology has the potential to assist in this goal by supporting the everyday tasks of older individuals, as well as by aiding caregivers and family members. Our platform will explore how computational capabilities can enhance day-to-day activities under Daily Life Activities Management environment. Smart home environments typically are equipped with different kinds of sensors and tracking devices for context-aware service provisioning. While on the one hand, people want to take advantage of the comfort and added value of personalized context-aware services, privacy and traceability becomes a serious concern on the other hand the computer is not a tool to be picked up, used, and then set aside. [20] It should be a constant partner in daily activities. The challenge is to design interfaces that reflect and support ongoing activities of daily life but not be inappropriately intrusive. ABLE will be designed to meet daily awareness needs of adult children concerned about the well-being of a senior parent, and another that can provide surrogate memory aids for household tasks. It will demonstrate the complexity of the issues involved in designing the computationally capable SMART home of the future and provide direction for future research and development efforts.

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