A TV-based ICT Platform for Active Ageing, Tele-care and Social Networking

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Abstract: The modern society is dealing with a progressive increase of the elderly population. The development of services for social inclusion and independent living is of paramount importance to enable the elderly to live in their homes autonomously as long as possible. Such a solution paves the way to a sustainable social and economic model where older adults develop self-confidence and promote their participation to the community life. This paper presents the hardware/software framework of a novel ICT system for active ageing support, which combines the potentialities of broadband internet services to the simplicity of TV use. User research in three European countries allowed to define several important services (healthcare, home monitoring, shopping, communication and social inclusion) to be provided through the developed platform. Its modularity, supported by the App paradigm, enables easy customization and future developments.

1 INTRODUCTION

Population ageing is a widespread phenomenon all over the world, resulting from the complex coexistence of many factors, such as the increased life expectancy, the choice of working parents to have less children than in the past, and reduced fertility (ESHRE Capri Workshop Group, 2005). According to (United Nations and Social Affairs, 2013), the global portion of older people, aged 60 years or over, increased from 9.2% in 1990 to 11.7% in 2013 and will continue to grow reaching 21.1% by 2050. Globally, the number of older people is expected to reach more than two billions in 2050 (Fig. 1 shows the projected population pyramid.) This has major social and economic consequences, since the healthcare expenditure increases along with the populations age because of the age-related diseases and disabilities.

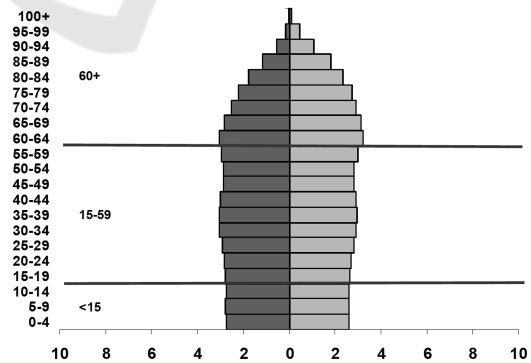

Figure 1: Expected 2050 population pyramid of the most developed regions (United Nations and Social Affairs, 2013).

The shortage of professional caregivers and the lack of facilities in which the elderly could be transferred in are exacerbated by the increasing number of older users (Rashidi and Mihailidis, 2013). Many elderly who live by themselves suffer from isolation for many reasons (Tomaka et al., 2006). With age, many of them suffer from mobility impairments and cannot leave their houses as often as they did before. As time goes by, the sons move out, sometimes in other countries, causing their parents to start living by themselves, older family and friends pass away and these facts lead to the shrinkage of their social networks. Also, there is often a lack of organization of specific social events, their publicity is poor, or it is difficult to access this kind of information.

Information accessibility can be hampered by another major issue that afflicts the elderly: digital divide. Digital divide can be territorial, i.e. lack of access to information and communication technology (ICT) and lack of broadband Internet access, or literacy-related, i.e. the inability to use certain devices. It is extremely important to take into account

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all these aspects to design and build a useful and user-friendly assistive technology for active ageing.

During the past years, many projects with the aim of helping older people to live in their homes autonomously as long as possible have been funded. Following this purpose, we have designed an integrated platform that will offer the elderly a variety of services to support them in managing various activities, directly from their houses, using the TV as medium. The use of TV can effectively reduce the risk of refusal due to digital divide, because it is present in almost every house since more than 50 years (Angius et al., 2008). TV is normally exploited for entertainment and leisure activities and has a central place in many elderly living rooms. Offering different kinds of social and support services, our platform will reduce the feeling of isolation and loneliness and help older adults to feel safe in their own homes. In this paper, we present the rationale behind the development of the proposed framework, from the user profiling to the main services development. Moreover, we describe the system in its present form along with the facilities for future extensions, which are natively supported by the developed framework. This version of the system is ready for the experimental trials that will be carried out throughout the 2015 in three European countries (Italy, The Netherlands and Belgium). This work is part of HEREiAM, a project funded by the Ambient Assisted Living Joint Programme (AAL JP, www.aal-europe.eu), call 5. AAL JP is a European funding activity that aims to help older adults through the use of ICT.

The remainder of this paper is organized as follows. In the following section we will describe other existing ICT platforms; in Sect. 3 we will briefly describe the user research conducted to profile our target group and to select and define the services we wanted to implement. The proposed platform architecture is presented in Sect. 4, whereas conclusions and future steps of the project are presented in Sect. 5.

2 RELATED WORKS

Creating ICT based solutions able to support older adults in different aspects of their lives is, nowadays, a critical challenge in our society. For this reason, the European Union (EU) is funding several initiatives (such as AAL, the European Innovation Partnership on Active and Healthy Ageing and the eHealth Action Plan) aimed at fostering the development of new ICT services, applications and products in a wide range of sectors, including healthcare, social policy, nutrition, security, mobility and transport. In this section, we will present some examples of research activities, recently funded by the EU, which propose solutions for the elderly following an approach similar to the one presented in this paper. An example of integration of technologies for health monitoring at home is provided by the four-year Dreaming project (Clemensen and Rasmussen, 2011). It provides a user-friendly technology, based on health monitoring, alarm handling and a TV-based videoconferencing service, to help the elderly and patients. This system provides a valuable support to both satisfy the users need of continuous care to safely and independently live in their homes, instead of being in a care institution, and to facilitate their social life and contacts with family, friends and caregivers. Another project, Care@Home (Fitrianie et al., 2013), additionally provides continuous remote monitoring of emergencies and lifestyle changes to manage or reduce risk factors associated with independent living. The project aims at defining an open platform, exploiting the Smart TV as the key front-end device. GeTVivid (Fuchsberger et al., 2012) is another example of a TV-centric platform that aims at stimulating and supporting daily activities at home through a rich set of services. The project is based on the Hybrid broadcast broadband TV (HbbTV) specification. The ELF@Home project (Carus et al., 2014) proposes a self-care solution capable of generating a personalized fitness program based on the health status and the continuous monitoring of activity level of the users. The system will comprise several parts including wearable activity and biomedical sensors, a simple TV interface for fitness sessions and a computer vision system to analyse fitness exercises execution.

Many other works are focusing on training games that could motivate older adults to remain socially and physically active. Long Lasting Memories (Bamidis et al., 2011) is an innovative e-health service that combines physical activity and cognitive exercises to prevent mental decline in the elderly. Join-in (Bolos et al., 2012) aims at counteracting loneliness in the elderly by providing a web-browser platform that connects to PCs or TVs to offer multiplayer video gaming, exergames and group exercising targeted at senior citizens.

This article focuses on the potential of an innovative TV-based system capable to offer a personalized set of services and information. With respects to the cited projects, the presented one aims at creating a flexible and open platform that simplifies the integration of externally-provided services. This will lead to the continuous expansion of the offered services, increasingly addressing the changes in user needs. Third parties can be part of the project ecosystem us-

ing the platform as a powerful tool to provide existing and new services directly to people that are familiar and confident in using TV but difficult to be reached due to their limited computer literacy. The proposed platform offers basic functionalities that third party's apps can use to promote their services. In fact, the proposed platform is able to extend its functionalities to health care facilities, home monitoring systems, educational and training video programs, shopping as well as social inclusion opportunities. The system compatibility with satellite technology guarantees full coverage in Europe, including rural areas where broadband might be slow or unavailable.

3 EXPECTED USERS PROFILING

Identifying needs, desires and limitations of potential elderly users is very helpful to create a valuable and successful platform. In the first phase of the project the target group has been identified through both desk and field research. Besides literature, user sessions have been organized in three different European countries (Italy, The Netherlands and Belgium). Based on a profiling questionnaire, the background of the user session participants has been investigated and characterized with respect to demographics, social situation, general lifestyle and ICT use. During the user sessions, older adults were invited and stimulated to work and play with a variety of existing service platforms. By applying observation techniques, think out loud protocols and post questionnaires, the usability of these different systems has been studied. After being sensitized, the participants were asked about their willingness in adopting such a service platform, the possible added value, the idea of having it on TV, the request for services, and willingness-to-pay. All participants gave their consent to the anonymous data collection and exploitation, accepting the study protocol. Analysing the answers given in the user profile questionnaire, it was possible to characterize the target users in the three pilot countries.

The users tests with Dutch and Belgian older adults were conducted in the Smart Homes demonstration house in The Netherlands (www.smarthomes.nl). Thirteen seniors from The Netherlands (average age of 71.24 ± 6.88, 8 male and 5 female) and thirteen from Belgium (average age of 78.15 ± 4.26; 6 male and 7 female) were invited for the profiling.

As for the participants from The Netherlands, nine of them had a college or university degree, i.e. the group was relatively highly educated. About computer usage, all participants use a computer (5 weekly, 7 on a daily basis), all but one use the Internet (1 less than once a month, 4 weekly, and 6 daily). Eight out of twelve participants never used a tablet. Ten of the participants use a mobile phone and everybody watch TV on a regular basis (10 daily, 2 weekly).

As for the Belgian elderly, ten of them had a college or university degree; again the group was relatively highly educated. With respect to computer use, the frequency of usage was lower than the participants from the Netherlands (5 never, 1 more than once a month, 4 daily, and 3 missing). Three participants never used the Internet and one participant reported to have used a tablet. Nine of the participants use a mobile phone and nine reported that they watch TV on a daily basis (4 missing).

In Italy, 29 expected users were recruited by convenience sampling from two local elderly associations. The group was composed of 14 males and 15 females, with average age of 70.1 ± 5.8. With respect to school education, three of them had a university degree, seventeen had an high school diploma and eight of them had a primary school certification (two missing). Figure 2 shows which technologies are mainly used daily by the Italian participants. As we expected, the majority watches TV whereas only half of them use PC and internet every day. The percentages for PC and internet are very similar, so it appears that most computer users also use the Internet. On the contrary, tablets are still a technology that the majority of elderly do not use.

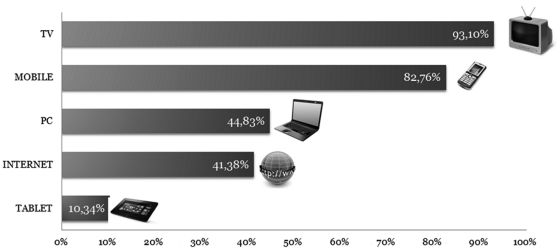

Figure 2: User profile questionnaire: analysis of the answers related to the daily use of ICT technologies, from Italian participants.

About how Italian participant spend their time during the day to perform different leisure activities, the results are shown in Table 1. Surprisingly, all participants prefer to perform outdoor activities (e.g. going out or physical activity), whereas they rarely play any kind of game (computer or board games, cards and puzzles). It emerges how participation in the community activities, and the feeling to be part of the community itself, is of paramount importance in the daily life of the interviewed elderly.

From the observations and discussions during the user sessions we can clearly conclude that the ma-

Table 1: User profile questionnaire: results related to the leisure activities.

How often do you perform the following activities?	Never	Every year	Monthly	Every week	Daily
Go out (e.g., shopping, bus trip, restaurant) with sb	6.90%	10.34%	20.69%	17.24%	44.83%
Organize social gathering/meals	10.34%	37.93%	24.14%	20.69%	6.9%
Physical activity (e.g., walking, sports, gym)	17.24%	3.45%	6.90%	27.59%	44.83%
Play card games	67.86%	14.29%	7.14%	3.57%	7.14%
Go to cultural events (e.g., museums, concerts, ...)	14.81%	33.33%	11.11%	22.22%	0%
Travel	13.79%	65.52%	17.24%	0%	3.45%
Play board games	86.21%	10.34%	0%	3.45%	0%
Craft work	17.24%	17.24%	13.79%	13.79%	37.93%
Play brain-teasers/puzzles	68.97%	6.9%	0%	13.79%	10.34%
Play computer games	72.41%	0%	3.45%	6.9%	17.24%

jority was enthusiastic about the possibilities offered by ICT-based service platforms. Nevertheless, differences between the platforms are reported and some difficulties emerged: mismatches in color and icon use, cumbersome remote control interaction, and inconsistencies in third party modules with regards to design and interaction. Flexibility in the offer of services is seen as beneficial. People have different kind of interests, and also different ICT skills. Some users will prefer a wide variety of services, whilst others will choose for a basic system with limited functionalities. Many of them are solely interested in being socially active and look for neighborhood activities, while others are interested in shopping services and the exchange of recipes and photos. Although people do not believe in such a service platform just for care, they do see the added value it can offer to manage their life in times of health deterioration. The concept of offering services via a TV platform is seen as a strong point. In particular, the large size of the screen and the social character are main benefits. The TV does not have a care-related or stigmatizing connotation, but can be seen as a gadget for comfort, joy and social connectedness. Since the TV has a prominent place in the living environment, it is also an ideal medium for reminders. The outcomes of the user needs analysis have been translated into service descriptions, requirements and technical specifications, in order to meet user needs, preferences and expectations.

4 PLATFORM ARCHITECTURE

Since the TV is the most known and used device by the majority of the elderly, as confirmed by the answers given in the user questionnaires (described in Sect. 3), we decided to develop a system based on it. Furthermore, we chose to create a platform based on the Android operating system, in order to facilitate third parties to enter our platform and offer their services, being able to seamlessly customize the system to the different regional uses and needs. A simplified scheme of the platform architecture is depicted in Fig. 3.

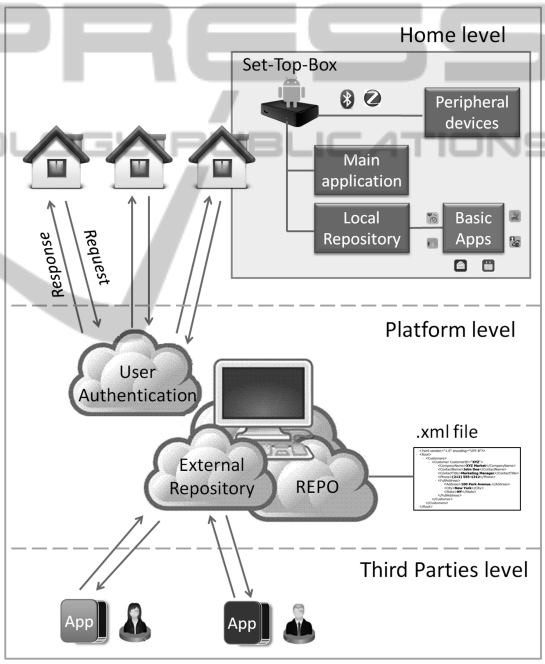

Figure 3: Platform architecture.

The Home Level is the part of our system that includes all the components of our platform installed in the users' homes. It includes all the hardware and software tools operating at home, that will be described more in detail in Sect. 4.1 and 4.2. Each home is equipped with a custom Set-top-Box (STB) with the system software installed on it, including the main application, which comprises a set of basic applications that are stored in a local repository. Some of these core applications, that will be described in Sect. 4.2.2, work in conjunction with external devices (e.g. telemonitoring devices, sensors and so on) exploiting a Bluetooth or Zigbee interface, according to the selected application.

The Platform Level is the server side of our platform. It includes information regarding user profiles, it contains an external repository of additional applications offered by third parties and a module that manages the users authentication system. In addition, the Platform Level hosts a Documental Repository Service (REPO) that allows the storage of data generated by each application in eXtensible Markup Language (XML) document format.

The Third Party Level includes all external stakeholders that may join the HEREiAM platform, which can be divided in two groups: the ones that already have their own Android application and all the others. Both the Home Level and the Third Party Level communicate with the Platform Level through a request/response mechanism. Third Parties cannot contact the users directly, and each communication needs to be registered and approved by the Platform Level.

In the following paragraphs, the main components of the system are described in terms of hardware components, software and services provided.

4.1 Hardware

As shown in Fig. 4, the hardware components of the platform are:

- Android custom STB,
- Personal smart card,
- TV with HDMI.
- custom remote control,
- satellite dish,
- external devices.

The Android custom STB is the core of the system. It is composed of a commercial Android TV Box, with the platform software installed, and a series of peripheral connected to its USB ports, like the remote control receiver, the smart card reader and others. It has many useful characteristics, like integrated webcam, microSD card reader, Ethernet port, Wi-Fi and Bluetooth. It can be equipped with the latest available version of Android operating system and connected to the TV HDMI port. The users automatically log in into the system by inserting their personal smart card into the reader, without having to manually enter their credentials. The TV is the mean through which the system is displayed and the custom remote control is the only device needed to interact both with the regular TV channels and the custom STB. The remote control will be user-friendly, provided only with the buttons effectively used (i.e arrow keys, numbers, colored buttons, back and home button, ON/OFF, OK

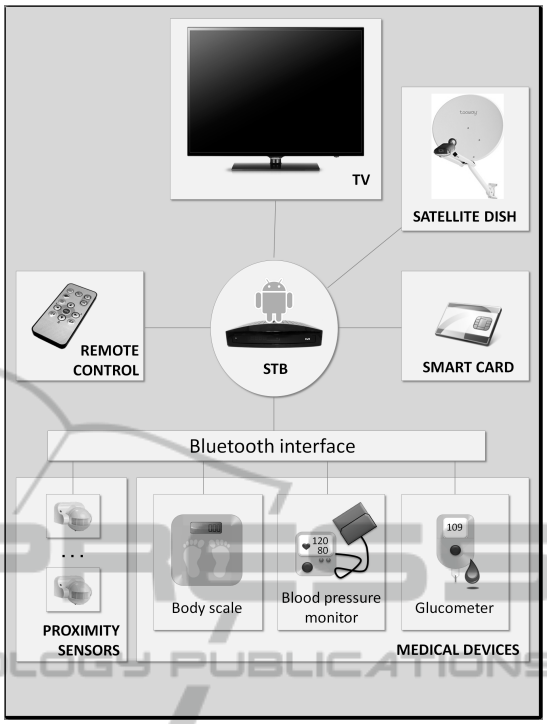

Figure 4: Hardware components of the platform.

and TV source). Since the system relies on an internet access to properly operate, the users who live in rural areas or that are not served by a broadband connection, will be equipped with a satellite dish to bring high-speed internet access via satellite. This particular service is available through the Project consortium and it is of paramount importance for the widespread diffusion of this support. Through the use of some specific services, it is possible to link the system with external devices (telemonitoring devices, home sensors, etc.). For example, it will be possible to measure some physiological parameters through commercial Bluetooth medical devices, visualize them automatically on the TV screen and receive feedback on them from the remote care staff. Some previous works pioneered the exploitation of the TV systems for this kind of application, exploiting the DVB-T STB rather than a general purpose one (Angius et al., 2011). Our system will include options to monitor and evaluate the users' lifestyles in order to predict safety problems (Khan and Sohn, 2012), similarly to commercial tools as BeClose (http://beclose.com/), CarePredict (http://carepredict.com/) and others, paying attention to the privacy issues reported by several elderly, completely reluctant to accept any video monitoring device at home. For this purpose, the system is able to collect data from home sensors: from their analysis it will be possible to send warnings either to

the users or to their caregivers. Typical alerts could be generated for reduced or altered mobility (Scanaill et al., 2006) or health-related habits.

4.2 Software

The platform is based on the Android operating system. The home software installed in the STB is written in Java and consists mainly of an Android custom launcher, an Android service running in background that handles various events that will be described hereafter, and the system applications out-and-out. The Android launcher, whose interface is shown in Fig. 5 and described in Sect. 4.2.1, represents the HEREiAM main screen and provides an overview of the installed apps. The custom launcher is programmed in order to display only the project-approved apps and hide all the other Android system ones. This homepage is the medium that is used by the subject to interact with the platform, in order to select the services, see the alerts and be informed if new events/messages are present. The users will have a customized homepage, that will display only the applications installed in their local repository, according to their profile stored in the servers. The Android service that runs in background will constantly check for updates, new events and messages to be delivered to the user. It is the mean used to exchange information between the Home Level and the Platform Level. The system apps share the same layout and the same navigation scheme between each other, to help the user avoiding confusion passing from one screen to another. A more detailed description of the system apps is given in Sect. 4.2.2.

4.2.1 User Interface

Nowadays, the proliferation of a new generation of hybrid end-devices (Smart TVs) and set-top-boxes is changing the TV consumption modes, combining the traditional broadcasting reception with the Internet-based transmission of attractive contents and services. Smart TV applications can give viewers access to large amounts of on-demand interactive services, providing a more engaging television experience. Unfortunately, some of them are not designed for elderly users that are novices regarding modern technological devices. Viewing Smart TV applications is very much like viewing web-pages using a browser on an ordinary PC, therefore it can be confusing and not really appealing for those older adults who have low computer literacy and limited web-browsing experience. Moreover, some of these applications are text-focused (such as Twitter, Facebook, and Youtube) so they require a keyboard or a touch-screen to be operated. For these reasons, within the project a comprehensive and attractive user interface (UI) has been created. This will ensure full participation and high user acceptance, overcoming the refuse of technological devices due to digital divide affecting the largest part of the elderly. The user interface is specifically designed for elderly and controllable with the remote control only. Besides general design guidelines (Nielsen, 1994), UI development has taken into account 10-foot user interface design principles.

The homepage layout, shown in Fig. 5, is composed of a white title bar at the top of the screen, a dedicated box for widgets below the title bar and a left/right scrolling grid of apps at the bottom of the screen.

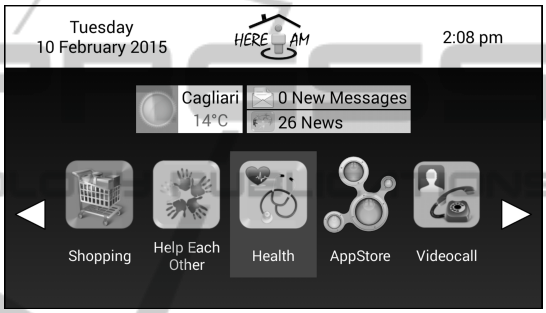

Figure 5: System home screen.

On the title bar, the current date, project logo and current time are always shown. The widgets below the title bar are configurable according to the user preferences. In the example shown in Fig. 5, weather forecast and notifications about new events and messages are present. Using the left/right arrow keys on the remote control, users can move the scrolling grid of apps to select the one they want to open. The selection frame always stays in the middle of the scrolling grid, while the icons move. To open the selected application, users have to press the OK button on the remote control. At any time, users are able to switch back to regular TV channels pressing the TV button on the remote control.

4.2.2 Services Included

The services provided by the platform can be grouped in the following four broad categories:

Medical Care. The elderly, particularly those suffering from chronic diseases, benefit from being involved with the management of their own health conditions. The mere fact of self-monitoring their physiological parameters gives them some degree of responsibility for their own care and improves their standard of living. Users will be able to self-monitor their

health status and feel more involved in their care process through the use of a health application.

- Health App - The Health App allows users to measure some physiological parameters - namely blood pressure, pulse rate, body weight and blood glucose level - using a set of medical devices installed at home and connected via Bluetooth to the Android STB. It also allows users to upload the collected data to a server, by simply pressing a button on the remote control, and make them available to a doctor (specified during the registration phase) for analysis. Health professionals can access data using a dedicated web page and can provide feedback based on their evaluation, including comments or advices that are stored in the platform database and displayed to the users at their next log-in.

Community Participation. The proposed platform will promote quality of life improvements for older adults, also limiting the feeling of isolation and loneliness by offering socialization opportunities and informal help through a community network. Interactions with family members, grandchildren, neighbors and friends are a vital component to the mental and emotional wellness of a senior. Many older people are no longer independent enough to participate in organized outdoor activities and need opportunities for social interactions, recreations and leisure activities at home. For this reason, the platform offers a set of social applications that will help the elderly and their caregivers to enjoy the feeling of being part of the community:

- Video-Calling: the Video-Call App offers great opportunities for social connection. It helps users to stay in touch with family members, relatives, friends and peers, increasing the sense of being together in a shared space at the same time.
- Help Each Other: the Help Each Other App is a dedicated platform for matching offers and requests. This application lets users offer or accept help from other community members such as volunteers, shopkeepers, caregivers, friends, neighbors and elderly associations. The scope of this service is to enhance users' independence, connecting people who want a service with people who are offering that specific service;
- Social News and Events: this application keeps the users updated on what is happening in the community and participate more in the activities or social events organized by local authorities (Municipality, Elderly associations, Clubs, etc.);
- Messages: the Message App allows the users to receive notifications on different topics, both from the platform basic apps (e.g. "request accepted" from another user of the Help Each Other App) and form third parties apps.

Security. For the elderly who live alone, getting help in an emergency situation can be a concern. Thanks to a network of wireless motion sensors installed at home (for example in the bathroom, in the kitchen or in the bedroom) and connected to the Android STB, the proposed platform will give users the confidence to live peacefully in their own homes and will ensure their safety.

- Alarm App: in case of absence of movement in the house within a predefined time slot, the Alarm App will automatically launch an emergency video-call on the user's TV and if no one answers, it will warn reference persons to check the status of user.

Support. To facilitate independent living, support daily life activities and promote memory training, the platform offers two additional services to the elderly:

- Agenda: the Agenda App allows users to schedule personal appointments (such as a doctor's appointment with date, time and location of the meeting) and reminders about daily or weekly chores such as taking medicine, paying bills, prescription refills or one-time events, directly from their homes;
- Shopping: being able to do the shopping is an important part of living independently. It is also a chance for elders to get out and meet other people. However, as people age, some uncontrollable events may prevent them from being able to do the shopping or hamper it, such as bad weather conditions, a short-term disability/illness, traffic congestion or strikes. The Shopping App lets users order on-line grocery items at local stores.

The modularity of the developed open platform, enabling the enrichment of the app set, will allow in the next future the integration of further services beyond the ones described above.

5 CONCLUSIONS

In this paper, the hardware and software framework of a novel ICT system for active ageing support is presented. The system, developed in the main path of an AAL Joint Programme financed project, tries to combine the potentialities offered by the broadband internet services to the simplicity of use of a TV set. Taking into account the reduced computer literacy of a

large part of the older population, especially in the rural areas, as emerged from the reported profiling studies, such a solution represents a valuable candidate to solve the digital divide problem. The rich set of developed applications, embedded in a common simple interface, aims to provide active ageing services to support the elderly in executing their daily activities independently from their homes, improving social inclusion and self-confidence. The selection of the App paradigm, supported by the Android operating system, enables the easy customization of the system to support both local specificities and individual customizations.

The main difficulties in the development of such systems are related to interoperability. As a matter of fact, supporting different medical devices (for the Health App), for instance, requires a considerable effort, especially if a support for old Bluetooth devices is sought. For this reason, the software framework natively supports a modular app paradigm enabling a smooth integration of third parties software to extend the basic system functionalities. During the next stages of the project, an evaluation study will be carried out through a combination of heuristic evaluation (expert review) and user testing (cognitive walkthroughs and observation). Later on, the system will be installed in a "demo room", in which the elderly could begin familiarizing with it. In the last six months of 2015 three pilot tests with 75 older people in total will take place in The Netherlands, Belgium and Italy, that will focus on usage/acceptance, quality of life and dependency.

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