ElderCare: An Interactive TV-based Ambient Assisted Living Platform

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Abstract

This paper describes the architecture and components of an AAL-enabling platform, centred around interactive TV (iTV), which combines OSGi middleware, RFID and NFC in order to ease the day to day of dependant or semi-dependant elderly people (its main focus), their care takers and relatives. The end result is an affordable, unobtrusive, evolvable, usable and easily deployable ICT infrastructure which aims to approach the vision of "AAL for All". This is, it seeks a more widespread adoption of AAL and a better QoS on caretaking through the combination of common hardware, OSGi dynamic service and mobile-aided care data management.

1. Introduction

Ambient Assisted Living (AAL) [1] fosters the provision of equipment and services for the independent or more autonomous living of elderly people via the seamless integration of info-communication technologies (ICT) within homes and residences, thus increasing their quality of life and autonomy and reducing the need for entering in residences or aiding it when it happens. This paper aims to explain the architecture and components of an AAL solution designed to give support not only to people in risk of losing autonomy but also to caretakers or people concerned about them (relatives or friends).

A common issue in AAL systems, inherited from the wider embracing AmI paradigm, is that deployment is limited to premises where an important economic investment and cumbersome ICT deployment can be justified. The main focus of this work is to define an AAL-enabling platform, namely ElderCare, which addresses this limitation. Hence, this paper mainly discusses the quest for a low cost, easily deployable, usable and evolvable ICT infrastructure leading towards "AAL for All". The fact that it must be usable by elderly people explains why the main interaction mechanism offered by this platform is interactive TV (iTV), i.e. the interaction with a device (remote control) with which everybody is familiar.

An important collective not usually targeted by AAL platforms is people concerned with or interested in the elderly people, e.g. relatives or friends who are not directly involved in caretaking. Hence, this work proposes different notification mechanisms to keep them up-to-date (e.g. email, SMS, RSS or Twitter) about dependant people evolution. Furthermore, it allows authorized care takers and relatives to access the ICT infrastructure aiding the elderly person in order to monitor or accommodate the system to their new caring requirements. In essence, the proposed solution is not only targeted to professional caretakers but also to relatives that want to enhance their elderly people's homes with some assistive support.

Another important and difficult issue to solve regarding AAL is to ensure adequate and timely care-related data management at residences and homes. In them, big amounts of data must be gathered and reported in real-time to be able to follow the progress and incidents regarding elderly people's daily routine. Only if proper care data collection is in place, better care for the elderly and more suitable working conditions for their care takers are possible. Thus, this work proposes to combine NFC mobiles and RFID tags to address this issue.

The structure of the paper is as follows. Section 2 gives an overview of related work. Section 3 presents the overall architecture of the ElderCare system. Section 4 offers more details on the three distributed component conforming ElderCare's modular, extensible and intelligent architecture. Section 5 draws some conclusions and states some future work plans.

Figure 1. AAL Kit (left hand side) and Interactive TV interface (right hand side).

2. Related Work

In [2], Standford describes one of the first AAL solutions: an instrumented elderly home that uses pervasive computing to help the residence's staff to easily identify where they are needed and to give them support to increase their work efficiency. Information is acquired by the system via locator badges, weight sensors in beds and so on, enabling the staff to better study and react to the problems that arise. Also in-apartment computers are used with custom applications to enable residents to communicate with the outside world and consume some services. The main limitation of the system is its lack of a capability for the seamless integration of new hardware. Besides, the system is designed to only operate within a residence.

The GatorTech Smart Home [3] is a remarkable 5 year long project that led to the construction of a very advanced smart house. A modular OSGi-based service architecture is defined that allows easy service creation, context and knowledge intelligent management and the integration of some custom-built hardware such as RFID plugs to easily identify connecting devices. Unfortunately, this solution can only be deployed in residences willing to make a big investment and go through a heavy deployment process. Its infrastructure is not suitable for widespread adoption. Besides, it does not address remote care giving at elderly people's homes, i.e. making the information and configuration accessible remotely for caregivers and family.

The iNEM4U FP7 project [4] focuses on enriching iTV experience by integrating community and interactivity services from various technology domains (social networks, in-home device networks) into an iTV session. They present an MHP based interactive TV prototype which uses a computer with VLC and MHP to build a TV Quiz application. Unfortunately, they focus on the connection of TV broadcast with external Internet services, but do not address the shortcomings of MHP technology to connect to in-house (often non-IP) devices or user-bound mobile clients. The reason being that MHP [5] decoders are limited to run applications that come embedded in the TV signal and run in a sandbox that only allows graphical interface rendering and IP communication with the Internet.

Some authors [6] have already extended MHP with proprietary extensions to interact with OSGi-based residential gateways. However, given the limited deployment at European homes of DVB MHP-compatible decoders and, even more importantly, the reliance on digital broadcasters to include MHP applications in the audiovisual carrousel, we have decided to adopt a proprietary but self-contained iTV solution.

Currently there are several interesting initiatives integrating computers in home living rooms with projects such as Boxee [7], XBMC[8] and MythTV[9]. However, few try to adventure outside the comfort zone of media playing and management. LinuxMCE[10] is one of the few that provides mechanisms to control home automation devices from any computer running the media centre solution.

The combination of NFC [11] technology and RFID tags has been used in several research projects related to medicine and caretaking [12]. Indeed, the adoption of mobile devices is making caretaking easier. Mei proposes the development of a framework that depicts patients' vital signs [13] and Tadj provides a basic framework for developing and implementing pervasive computer applications [14]. However, few if any have offered solutions to store the most relevant information regarding the residents themselves, their symptoms and the caring procedures applied in their identifying wristbands, so that care data management can be improved.

3. The ElderCare Platform

This platform is devised to provide universal ICT support for more *friendly aging* at homes and residences, i.e. how to preserve and elongate the autonomy of people through technology despite their increasing dependency needs. It aims to define a minimum but sufficient set of off-the-shelf hardware and accompanying software infrastructure, named *AAL Kit*, which is easily portable, deployable, configurable and usable in either elderly people homes or in their rooms in residences. It is thought to be accessible to any elderly independently of their socio-economic, cultural or technological background.

In the proposed solution, see Figure 2, local deployments of AAL Kits are remotely managed by a centralised back-end server which allows residences or institutions monitoring elderly people homes to control, notify and be alerted from the assisted environment. Notably, this platform brings about usable and accessible interaction interfaces best suited for the three collectives targeted in ElderCare: a) first and foremost, elderly people living at their homes or in residences are offered an interactive TV interface; b) caretaking staff request and register info about their caring procedures through NFC mobiles and touch screens; and c) authorised relatives and friends interested on and concerned with following the elderly people's life logs, follow them through RSS or micro-blogging services such as Twitter.

In essence, the ElderCare platform aims to provide a holistic ICT infrastructure for AAL in any home or residence that is affordable, unobtrusive, easily deployable, usable, accessible and evolvable. In other words, this solution addresses the following design requirements:

- *Affordable* since it has to be offered at a low cost to ensure anybody can purchase it. Therefore, it should be built using mass-produced off-the-shelf hardware. In our prototype, the following elements have been used: a TV tuner (68 €), a small size motherboard (84 €), a 2 Gb RAM module (45 €), 1 120 Gb hard drive (30 €) and 1 set-top-box like PC box (35 €). All of it amounting to a total of 265 €, a price that could be reduced significantly if such a product was to be produced massively. Other additional and optional elements used in our prototype have been a ZephyrTM HxM Bluetooth biometric belt (160 €), a Bluetooth USB adapter (20 €), a Nabaztag Internet-connected object (145 €), 1K HF RFID wristbands (0,3 €/unit) and NFC mobiles (150 €/unit).
- *Unobtrusive* so that it can be seamlessly integrated within a home or residence room, i.e. it should have the form factor of other common electronic devices, without cluttering the environment where they are deployed, or be easily worn by users. Our solution takes the form of a small PC or set-top-box, see small black box next to the phone in Figure 1. Furthermore, residents are encouraged to wear a lightweight silicon wristband and optionally a more intrusive biometric belt in order to monitor their vital signs. Only in this latter case we could state that our solution is slightly intrusive from the residents' point of view. On the other hand, caretakers are only encouraged to carry a mobile phone. Therefore we can state that our solution in this case is not obtrusive.
- *Easily deployable* so that relatives or even elderly people can plug in the system and configure it. In our case, the proposed set-top-box-like hardware is directly connected to the TV and only needs a button press to be started and operates, in its default mode, as a standard DTT decoder.
- *Usable and accessible to every user collective*. Elderly people accustomed to use a TV remote control can easily use the offered Teletext-like interface. On the other hand, care staff is provided with efficient and rapid access to the platform services through touch screens or intuitive mobile phone applications. More advanced users access ElderCare from remote PC browsers through a simple RIA (Rich Internet Application) web front-end, see Figure 4. Finally, authorised relatives and friends can follow a dependant person's daily caring logs through

notification mechanisms such as email, RSS or Twitter. In summary, ElderCare attempts to offer those interaction interfaces best suited to every different collective.

- *Evolvable*. It should be easily integrated with any existing or emerging home automation devices (e.g. X10, Zigbee Home Automation, KNX), notification mechanisms and assistive services. Furthermore, it has to cope with the fact that the assistive services demanded at a premise vary in time, and so do the sensors, actuators or Internet services required. Bearing this in mind, ElderCare has been designed around OSGi, a service infrastructure devised to cater with the heterogeneity and dynamicity requirements mentioned.

3.1. ElderCare Platform Components

The ElderCare platform addresses the aforementioned requirements proposing a distributed architecture with the following three components:

- *AAL Kit* – a set of essential hardware and software components which can be deployed in any home or residence room to aid personal autonomy. Figure 1 shows the form factor of the AAL Kit, constituted by a set-top-box like element connected to a TV. As a matter of fact, it acts as an enhanced DVB-T decoder which offers data services to elderly people and controls the devices deployed in their habitat. Its software, named *ElderCare's Local System*, see Figure 2, provides a set of default assistive services which are described in §4.
- A central remote management and service provisioning system, namely *ElderCare's Central Server* (see top of Figure 2). It remotely manages the Local Systems deployed in the rooms of a residence or in different homes. It collects data gathered at those installations, stores and analyses them and generates notifications via different mechanisms in order to report care staff or relatives about important events associated to elderly people. Importantly, it offers an AAL service repository, something like an "AAL store", which can be accessed using web browsers to select, download and install new services. For instance, a "food shopping from TV" service. All the services currently deployed in a given AAL Kit can be reviewed by accessing to the Services menu option (see selected tab in Figure 4).
- A mobile client to assist in care logging, namely *Mobile Care Logging System* (left part of Figure 4 and Figure 5). It is used by relatives and care staff to record, through NFC mobiles in elderly people's RFID wristbands, events and caring procedures performed over them. Care logs stored in RFID wristbands are also reported by mobiles regularly through Bluetooth to the Local System which forwards them to the Central Server which then notifies non privacy invasive selections of them to relatives or friends.

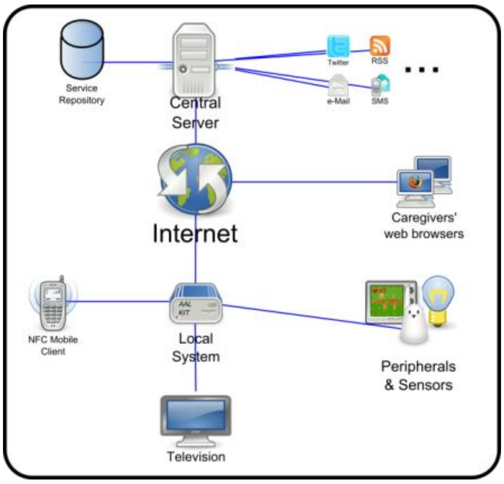

Figure 2. ElderCare Architecture.

4. Implementation Overview

This section offers a more detailed and low-level description of the three distributed components conforming ElderCare's system architecture (see Figure 2).

4.1. ElderCare's Local System

Internally, an ElderCare's Local System is governed by an OSGi server (deployed on Equinox [15]) which manages the following set of embedded default bundles:

- *TV Tuning and Widget Manager*. It generates the interactive TV main interface offered by a Local System. It behaves as an enhanced DVB-T decoder which performs widget rendering on top of TV images captured from a TV tuner card when requested by OSGi bundles executing in the local system.
- *Home Automation Manager*. This service allows communication with different widely available building automation standards such as X10, Zigbee or KNX, encountered in any modern or previously instrumented home.
- *Alert Manager*. Alerts may be programmed locally or remotely and registered in an internal scheduler. Generally, alerts will be rendered in the TV screen, see alert on TV in Figure 1, although other alternative channels when the TV is off are possible such as TTS through the set-top-box speakers or a Nabaztag (left side of Figure 1).
- *Elderly Vital Sign Monitor*. Vital sign data collection and analysis from a Zephyr HxM biometric wireless vest [16] has also been integrated. Such vest communicates, through Bluetooth, vital variables like heartbeat rate, ECG or distance walked. The data collected can then be reviewed through the Local System web interface (see Log icon in Figure 3). In addition, health risk alerts are identified and reported to the Central Server which notifies the relevant people.
- *Service Manager*. This core service provides the extensibility capability of a Local System. It allows to install/un-install services dynamically without system reboot. It also gives access to all the logs generated by the assistive services currently run at an AAL Kit instance. For all of this, it leverages on OSGi's service management capabilities through the `BundleContext` class[17]. Figure 3 displays in the Local System's web front-end an extension service which can be selected for installation.

An interesting feature of ElderCare's Local Systems is their capability to render graphical user interfaces on top of digital TV. Unfortunately, Java support for multimedia management, through JMF, is limited both in terms of the media formats it supports and its performance. Thus, an alternative in the form of an external non-Java application has been used which fulfils that role. Such tool is MPlayer [18], i.e. an open source multimedia player which supports most of the currently established media types and offers a command-line interface (CLI).

Figure 3. Local System's Web Front-end.

Something remarkable about ElderCare's interactive TV interfaces is that they are thought to be easily controllable through the TV remote control by requiring only numeric input or navigation and selection using the remote's custom cursors and the OK button (see alert painted on screen on right hand side of Figure 1).

4.2. ElderCare's Central Server

The Central Server offers a unique façade from which managers of Local Systems (relatives or staff in a residence) can control ElderCare deployments. Figure 4 shows ElderCare's central server's web front-end developed with GWT, a Google toolkit which transforms Java developed interfaces into RIA applications. This front-end allows the configuration of a given deployment. For example, all the residents and staff details within a residence. Moreover, it allows the control of every local system deployment.

This Central Server is also responsible of managing the changing connection details of individual Local Systems. In standard home settings, these are mostly associated to non-public IP addresses that may change from one day to another. Therefore, Local Systems have to regularly report their currently assigned IP address to the Central Server. Thus, the Central Server always available at the same domain name is aware, at any time, of the current connection and status details (ON/OFF) of a Local System.

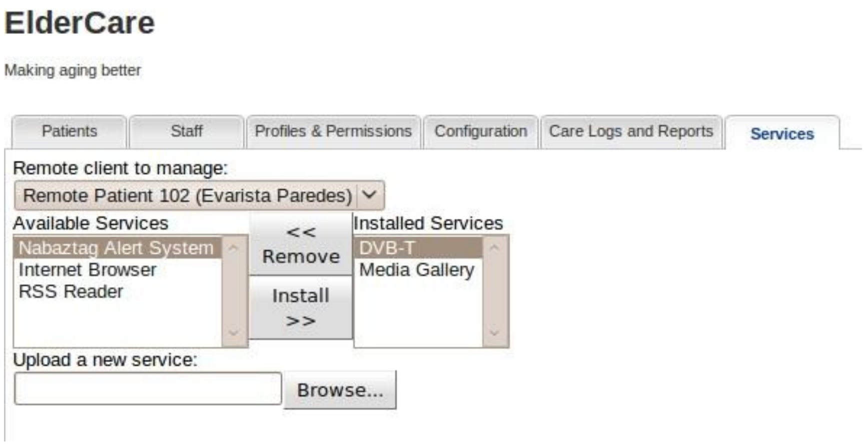

Figure 4. ElderCare's Central Server Web Front-end.

An interesting feature of the Central Server is its capability to react, autonomously, to unexpected or emergency aspects in Local Systems. For that, it includes a rule-based system which adds reactive behaviour. Thus, when an anomalous situation is detected by any of the services deployed at a Local System, a rule maybe triggered that notifies the residence staff or the elderly person's relatives to take action. The most interesting feature of this rule-based reactive system is that different rule engines may support different rule types (discrete and fuzzy rules) given that there will be different rule and knowledge base pairs coexisting, where each pair may be associated to a given Local System or even to specific service instances within it.

4.3. ElderCare's Mobile Client

Recording care data through an Internet-connected PC is infeasible outside a caring centre. Often, relatives or external caretakers do not have Internet access, they are not computer-literate, and, in case of having access to a PC, they often postpone the data reporting process. Even within a residence, care data reporting through a PC is a non real-time activity prone to losing many details on the way, due to their busy work shifts. Therefore, recording caring logs *in situ* through an NFC mobile phone and an intuitive mobile logging application, such as the one shown in Figure 5, on HF RFID tags worn as wristbands or watches by residents is a much more feasible approach for suitable care data logging. Furthermore, the most recent and relevant care information remains at all time in the resident's wristband, so that without a network link any caretaker can quickly review a resident's care status.

In order to prove the viability of recording care logs in RFID tags, a sample of 234 stereotypical care logs were considered, taking into account common redundancies in care logging. For example, the same caretaker may apply several caring procedures to the same resident during a day, most of the logs will be at the same location, the same message (e.g. "fell asleep") may be taken several times in a day, and so on. Considering average care logs of 56 characters, a total of 34 and 164 messages could be stored in the 1K wristband and 4K watch RFID tags considered, after applying ElderCare's data encoding format. According to care experts, such number of logs is sufficient, even with 1K wristbands, to store all the logs gathered for a resident in a day.

5. Conclusions and Further Work

This work has shown a novel AAL platform offering three distinguishing features: a) the ICT infrastructure provided is affordable and easily deployable at both elderly people's own homes or in their residences, b) the infrastructure does not only primarily target elderly people's assistance but also helps caretakers in their work and properly keeps relatives and friends up-to-date on their evolution and c) it alleviates data

Figure 5. ElderCare's Mobile Client.

management in care taking by combining NFC mobiles and data storage on RFID tags. Importantly, the ICT infrastructure proposed approaches the ideal of "AAL for All" by being not only low-cost and easily deployable, but also attempting to ensure high user acceptability in terms usability and accessibility, thanks to its iTV, RIA and NFC interfaces. Finally, it leverages on OSGi service management capabilities to ensure service evolution, i.e. the capability to dynamically extend its functionality and cope with changes.

Future work will put the ElderCare platform in practise in a real deployment, a residence recently created which will be opened in July 2010. This will allow us to verify the goodness and limitations of the promising ElderCare ICT infrastructure. Technically, future work will also consider including videoconferencing capabilities between Local Systems and the Central Server or even authorised remote Local System managers.

References

[1] Ambient Assisted Living Joint Programme, http://www.aal-europe.eu, 2009.

[2] Stanford V.: Using Pervasive Computing to Deliver Elder Care, IEEE Pervasive Computing, vol.1, no.1, pp. 10-13, ISSN:1536-1268, 2002

[3] Helal S., Mann W., El-Zabadani H., King J. et al.: The Gator Tech Smart House: A programmable Pervasive Space, IEEE Computer, vol. 38, no. 3, pp. 50-60, March, ISSN:0018-9162 , 2005

[4] Hesselman C, Derks W, Broekens J, Eertink H, Gülbahar M, Poortinga R: An Open Service Infrastructure for Enhancing Interactive TV Experiences; EuroITV2008 Workshop on Sharing Content and Experiences with Social Interactive Television (2008)

[5] Digital Video Broadcasting (DVB): Multimedia Home Platform (MHP) Specification 1.2.2., http://www.etsi.org/deliver/etsi_ts/102700_102799/102727/01.01.01_60/ts_102727v010101p.pdf, 2010

[6] Díaz-Redondo R., Fernández-Vilas A., Ramos-Cabrer M. and Pazos-Arias J.: Exploiting OSGi capabilities from MHP applications, Journal of Virtual Reality and Broadcasting, vol. 4, no. 16 (2007)

[7] Boxee; http://www.boxee.tv/ (2010)

[8] XBMC; http://xbmc.org/ (2010)
[9] MythTV; http://www.mythtv.org/ (2010)
[10] LinuxMCE; http://linuxmce.com/ (2010)
[11] NFC Forum.: NFC Forum Website. http://www.nfc-forum.org, (2009)
[12] Bravo J., López-de-Ipiña D., Fuentes C., Hervás R., Peña R., Vergara M. and Casero G.: Enabling NFC Technology for Supporting Chronic Diseases: A Proposal for Alzheimer Caregivers, AmI 08 – European Conference on Ambient Intelligence, Lecture Notes in Computer Science, Proceedings of AmI 08, vol. 5355, (2008)
[13] Mei H., Widya I., van Halteren A., Erfianto B.: A Flexible Vital Sign Representation Framework for Mobile Healthcare, Pervasive Health Conference, November 2006.
[14] Tadj C and Ngantchaha G.: Context handling in a pervasive computing system framework, 3rd international Conference on Mobile Technology, Applications &Amp; Systems Mobility '06, vol. 270. ACM, 2006.
[15] Eclipse Equinox website, http://www.eclipse.org/equinox/, 2010
[16] Zephyr™ HxM biometric vest, http://www.zephyr-technology.com/hxm.html, 2010
[17] OSGi Alliance.: OSGi Alliance Home Site; http://www.osgi.org/Main/HomePage, (2010)
[18] MPlayer Home Site; http://www.mplayerhq.hu, (2010)