ADAPTIVE SERVICES FOR ELDERLY PEOPLE AND CAREGIVERS IN 'ASSISTED LIVING' HOMES

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Abstract: This paper presents an innovative medical grade telecommunication system (combining professional and consumer equipments) and its service platform extended with a personalization technology to automatically adapt the services to the end-user disabilities, preferences, and context. This system has been developed in the scope of an 'assisted living' home and several applications have been demonstrated upon it (e.g., activity proposition, reminders, and alerts). Such demonstrations have highlighted the added value of the adaptation technology to enhance the quality of life of elderly people as well as the efficiency of the caregivers' work.

1 INTRODUCTION

The population of the world is aging. According to the World Health Organisation (WHO, 2004), there were about 600 million people in the world aged over 60 in 2004. By 2025 this total is expected to double and by 2050 it is projected to reach two billion (21% of the total global population). In Europe, this trend is even more pronounced as the percentage of population aged over 65 is expected to reach more than 28% by 2050 (SHARE, 2005). Such accelerated population ageing will impact social and health care demands in all countries.

Maintaining high quality of life, autonomy, wellbeing and social inclusion of the aged population as long as possible is a wish of governments and health authorities. The preference is often in favour of keeping old people at home since it is less expensive than in institutions, at least for those with a low level of dependency.

As the prevalence of disabilities and dependency increases with age, then nursing or assisted living homes are frequently the only solution. In these institutions, personal services include a safe and secure environment, supervision and assistance as well as activities of daily living such as medication prescription, bathing, hair dressing, eating, laundry, entertainment, etc.

Up to now, alerts or assistance requests are sent to professionals through dedicated devices (such as pagers) and systems, which do not allow for efficient coordination. Moreover, residents being not aware of the progress of their requests, tend to call again and again, thus increasing stress and workload for the caregivers.

The multiple problems encountered by the professionals in home care for elderly, due to the varieties of medical and mental situations, in addition to inappropriate communication equipment, lack of coordination, stress and workload, can lead to inadequate professional health management.

Information and Communication Technologies (ICT) now offer real opportunities to make more efficient and cost effective healthcare and assistance to elder residents as well as to provide an effective support to health professionals and nurses. Sensors can be used to monitor daily living activities, home automation devices make the environment more controllable and various terminals with user friendly interfaces allow an easy communication with

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everyone. Residents can feel secure knowing that assistance is available anytime even if they are unable to request it themselves, and nurse staff can have peace of mind knowing that they will be alerted when assistance is needed (Ghorbel et al., 2004).

In this context, this paper presents an innovative medical grade enterprise telecommunication system for an 'assisting living' home and which combines professional and consumer equipment. This new environment improves the quality of life of elderly people as well as the efficiency of the caregivers' work in their daily life. The presented technology includes a dedicated service platform with personalization capacities to automatically adapt the services to the disabilities, the preferences, and the contexts of the end-users. In this platform, the service adaptation is performed over various terminals (e.g., PDA, laptop, IP phones, and TV) and takes into account some semantic information on the services (e.g., purpose of a notification, topics of the delivered information) as well as on the user profile (e.g., interest domains, preferences, and disabilities).

This paper is structured as follows: an overview of the networking infrastructure of the residence is given in Section 2. Section 3 presents the dedicated adaptive service platform with a particular emphasis on the adaptive notification mechanism. The definition and usage of possible applications are also presented. A concluding discussion in Section 4 completes the paper.

2 NETWORKING INFRASTRUCTURE OF THE 'ASSISTED LIVING' HOME

In order to enhance the Quality of Life for older adults and the efficiency of their caregivers in a rural 'assisted living' home, we propose an innovative medical-grade infrastructure which offers various e-Health and daily living services.

The proposed networking architecture is depicted in Figure 1. It is based on an IP private network deployed over an 'assisted living' home and is composed of an extended IP-PBX (IP telephony switch) with a service platform allowing to offer services to each resident (i.e., elderly people) and to the medical and administrative staff.

In this networking architecture, the *personal room of each resident* is equipped with a fixed IP phone (including a small screen) and a TV with its IP Set-Top Box (STB). Services can be delivered by intelligently combining these two devices. Moreover, wireless capabilities are available in each room to connect, if needed, additional devices such as wearable sensors, PDA, etc. Fixed sensors (e.g., video cameras for detecting abnormal postures such as people falling) can also be installed in this personal resident room.

The *residence common places* (e.g., restaurant, library, and garden) are also equipped with WiFi access points to keep the connection with the wearable sensors as well as with all the PDAs of the medical staff. Indeed, each staff member holds his own PDA to communicate with the residents and to the other staff members, but also to consult his agenda, to know the care she/he has to give to a resident or to consult the medical file of a resident.

Moreover, a *special medical room* can be made available inside the residence for an automatic check-up of the key health parameters of a resident. For instance, this room can be equipped with a medical chair, connected to the residence IP network, and allowing to measure parameters such as blood pressure, cardiac frequency, body temperature.

The *doctor/staff office* is equipped with a fixed IP phone and a PC/laptop to access all the infrastructure services and to administrate the system (e.g., set the user profiles and preferences, manage the privacy of these information, and make the service subscription and configuration).

Finally, this networking infrastructure also allows the staff members (and the residents as well) to stay connected with the system and the provided services outside of the area of the nursing home. This is done thanks to a specific software client installed in the PDA and which allows the use the public networks (such as GPRS, 3G, WiMax or even public WiFi hotspots) to keep access to the services outside of the residence network area.

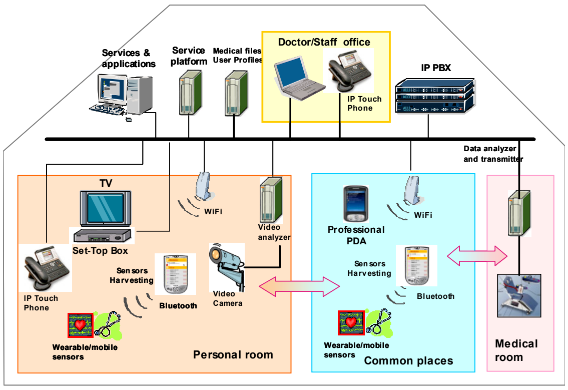

Figure 1: Networking infrastructure of the 'assisted living' home.

3 ADAPTIVE SERVICE PLATFORM FOR ‘ASSISTED LIVING’ HOMES

3.1 Service Platform

A service platform is running above this networking infrastructure (combining IP-PBX and TV-STB environments) and allows to easily create, deploy and execute new services ranging from communication between people, information push, social participation, entertainment & leisure activities, mental exercises, care giving support, patient medical monitoring, and critical e-Health services such as alerting. These services rely on the different modules of the IP-PBX platform (e.g., call server, notification, user profile, user privacy management) as shown in Figure 2.
Moreover, this service platform integrates a technology to automatically adapt the service according to its semantics and to the user characteristics (e.g., his preferences and disabilities). For instance, when notifying an information to a resident (as an appointment with the doctor) and based on the semantics of this information and on the resident profile, the system automatically selects the right device to display this reminder (e.g., the IP Phone or the TV) and the best way to trigger this notification (e.g., using a sound alert followed by an automatic reading of the message). Indeed, having such adaptation features is key for services delivered to elder people, each one having his/her own disabilities, preferences, etc. This adaptation intelligence will be described in more detail in the next section.

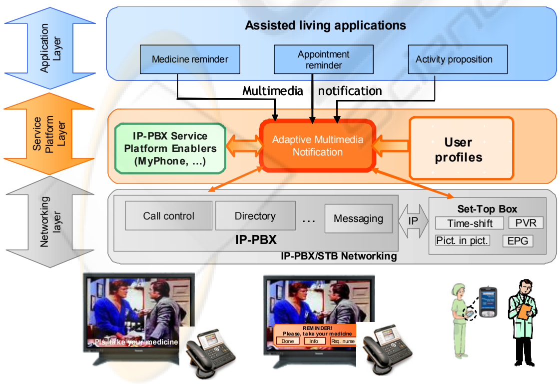

Figure 2: Service platform of the ‘assisted living’ home.

3.2 Adaptive Notification Mechanism

Several types of information may be notified to residents and/or professionals: alerts, reminders (e.g., medicine or appointment reminder), activity proposition (e.g., event proposal as tourism visit) or new contents that could interest the end-users (e.g., medical information or a new available VoD). However, due to the multitude of usable formats (e.g., text, image, audio, and video) and the diversity of targeted terminals (e.g., PC, PDA, STB-TV, Smartphone, and IP phone), it becomes very complex for an application to select the right delivery mode while also taking into account criteria such as the semantics of the notification, its priority, the end-user preferences and disabilities (limitations), their contexts, or the device capabilities.

Such a diversity is not tackled by existing adaptation approaches which are performed at a network level by adapting a service to the network and terminal characteristics (Gioia et al., 2004; He and al., 2007) or which target a specific environment such as the web (Brusilovsky et al., 2007; Caldwell et al., 2008). Other solutions address part of the problem taking into account only the end-user context or are specifically focused on alarm notification management (Paganelli et al., 2007; Broens et al., 2007). But none of them supports all the types of applications and terminals, nor the various adaptation criteria such as content semantics and criticalness, user profile and disabilities, or user reachability.

For this purpose, we propose an adaptive notification enabler that automatically selects –for a wide range of applications– the right delivery mode and optimizes the impact and efficiency of the notified information (Arlein et al., 2008). From semantic information on the notification (e.g., purpose of the notification, topics of the delivered information), this enabler automatically determines *when* (delivery time), *how* (delivery channel, display rendering, notification behaviour, terminal behaviour), *what* (part of content to be displayed) and *who* (person(s) within a group) will receive the notifications.

The main components of this enabler are presented on Figure 3 and further described below.

The adaptive notification enabler receives therefore various types of notification from different applications (e.g., medicine reminder, appointment reminder, activity or content proposals, e-Health alerts, and people requests). See some examples of such notifications in Figure 3.

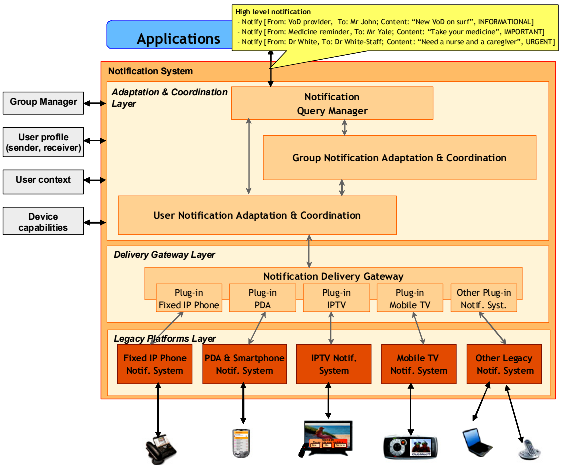

Figure 3: Architecture of the adaptive notification enabler.

The *Notification Query Manager* manages these requests sent by the applications (translation into internal format, validation and routing to the user or group adaptation modules) and the responses coming back from the adaptation & coordination layer.

The *User Notification Adaptation & Coordination* module adapts the notification to a single user and automatically performs adaptations such as:

- select the most appropriate terminal,
- determine the best time to deliver the notification to the end-user (e.g., immediately, at the end of viewed TV program, during a related TV program, in a specific context as 'at lunch time in the restaurant'),
- adapt the device behaviour (e.g., time-shift, text-to-speech, and beep),
- adapt and/or filter the notification content (e.g., displaying all or part of the initial content),
- adapt the notification graphical rendering and possible interactivity (e.g., informational message, acknowledgement needed, and call trigger).

Such adaptations are performed according to criteria such as:

- the end-user preferences and interest domains (e.g., preferences in music or movies, usual leisure), and disabilities (e.g., blind person), as well as the user privacy policies on these data,
- the terminal type (e.g., TV, PDA, IP phones, and PC) and its characteristics (e.g., screen size, content format supported, and remote control possibilities),
- end-user and device context (e.g., presence, location, terminal state, current activity, and current active TV program),
- the notification characteristics (e.g., content semantics, priority or criticalness).

All these adaptations are defined by user notification policies or rules.

The *Group Notification Adaptation & Coordination* module adapts a notification sent to a group of users (or to a community). It automatically defines in which order the members of this group will be notified (e.g., simultaneously, sequentially, on a role-basis or with any other group notification strategy defined by group notification policies/rules) taking into account various criteria (e.g., profile of the sender/receiver, role of each person in the group, and semantics of the notification).

The *Notification Delivery Gateway Layer* translates the terminal-specific adaptations related to the notification display and rendering, and defines the behaviour of the end-user terminal when the notification is displayed (e.g., put the TV in a time-shift mode, decrease the TV volume). It also handles the end-user interactivity which can for instance – with his TV remote control– trigger a call, schedule an appointment, or even trigger another notification.

The *Legacy platform Layer* actually sends the notification to the terminal using the device driver of the selected terminal.

3.3 Implementation and Demonstrated Applications

This adaptation architecture, using end-user profiles, terminal capabilities and notification semantic, has been implemented and experimented.

Concerning the technology, the interface of the notification system with the applications has been implemented using Web Services (SOAP) and deployed on an open source application server (Tomcat). The professional PDA is equipped with Windows Mobile 6 and includes IP telephony capabilities through a SIP client. TVs are connected to commercial IP STB running on a Linux OS. The use of such common technologies will facilitate the portability of the solution in different environments.

These network infrastructure and the adaptive service platform have been demonstrated on three e-Health applications notifying three different types of information: entertainment activities, appointment reminders and health alerts.

Entertainment activities (e.g., visit of a city or proposition to attend a concert) are proposed to the residents of the elderly home care unit. The information is displayed on STB/TV in a different way (e.g., blocking or non-blocking pop-up, with automatic text-to-speech, with possible interaction using the TV remote control) depending on each resident’s profile, preferences (e.g., music or tourism) and disabilities (e.g., reduced sight or hearing loss).

Appointment reminders are displayed on TV through blocking pop-ups to recall an appointment (e.g., medical appointment) to a resident and propose the optional help of a nurse (e.g., to get ready for going out). In this case, the system expects a response from the resident. After a limited time, if the resident has not acknowledged this reminder, the system performs a second attempt –more insistent– by reducing the TV volume and playing an audio message such as: ”You have not acknowledged an important message. Please do it now!”. If the second pop-up is not acknowledged either, a nurse is automatically notified on her PDA that the resident may have a problem. This mechanism is called “notification escalation”.

Health alerts are generated towards nurses when a suspect situation is detected (e.g., by sensors as cameras or on-body sensors) and confirmed as actually abnormal after a correlation with other collected information. Such correlation allows for instance to deduce that the person is fallen or going out of the room during the middle of the night.

3.4 Feedback

A preliminary analysis, based on interviews and questionnaires, has been performed to retrieve user needs of the main stakeholders of the system: healthcare professionals and residents (Reerink Boulanger et al., 2008).

Other feedback has been collected from direct demonstrations to professional stakeholders (e.g., caregivers, institution managers, etc.).

Professional caregivers were interested by the user friendliness of the system for receiving alerts and they confirmed that this system is of great value in improving their staff’s day-to-day efficiency and to ensure traceability of the processed events.

Institution managers approved that a personalized approach of both entertainment and medical information delivery is very important for residents since gathering such information is key to maintaining their social links and to establish a secure link between them and their care givers.

Moreover, software editors appreciated the possibility to extend their applications with workflow functionalities by using the multi-terminal notification API.

Finally, this new technology also raised a strong interest from software integrators who see new technical opportunities emerging from advanced solutions that mix consumer equipment such as interactive TVs and professional enterprise infrastructure.

Deep ICT social acceptability and extended usage analysis experimentations will be carried out within the assisted living home to further analyze and well appreciate the improved quality of experience of the end-users (both professionals and residents) in his or her daily life.

4 CONCLUSIONS

In this paper, we have presented an innovative environment to deliver and adapt services in an assisted living home. In particular, this technology includes an adaptation layer for the ‘intelligent’ processing of notification delivery. Indeed, as communication environments converge, people have more ways to send and receive multimedia information – through various channels, networks, and devices. The proposed solution allows notifications to be efficiently generated, distributed, and displayed in these new, diverse environments. Indeed, based on semantic information, the notification delivery is tailored to the receiver(s) profile, current location, context, activities and available/active devices.

The system has been demonstrated on different notification scenarios such as an alert generated toward the medical staff, an activity proposal to the residents, or the reminder of an appointment to a resident. Notifications are routed over an IP-PBX using one or several of the following devices: TV/Set-Top Box, fixed IP phone, WiFi phones, PDA or PC. The carried out demonstrations have highlighted the added value of the adaptation technology which simplifies the work of the sender, increases the quality-of-experience of the receiver as well as the impact and efficiency of the notification.

In addition to its service platform, this networking environment presents the following:

- It enables the creation of new services combining the capacity of telecom devices (IP phones, WiFi PDA), media devices (television), residential gateways (Set Top Boxes) and of a central communication system (IP-PBX with its service platform) in a residential environment.

- It supports the connection with new innovative sensor technologies either embedded with the resident (e.g., on-body sensor to detect e-Health problems) or installed in the resident environment (e.g., camera to detect abnormal situations or postures).
- It offers a mobile and transparent access to the services (thanks to a client software embedded in the PDA) either inside or outside of the 'assisted living' home and whatever the wireless access technology.
- The system is defined in a nursing home in a rural environment. However, this architecture and approach could be applicable as well for home networks (using the service platform of the public operator, or with a VPN between the user home and the nursing home/hospital).

The investigated applications aim at supporting both elderly residents in their everyday life and health professionals in their working tasks with an enhanced communication experience. Indeed, the proposed networking architecture and its service platform allow to create new innovative services covering a large spectrum of requirements: daily living services (e.g., entertainment), well-being services (e.g., mental exercises) and e-Health critical services (e.g., alerting). Nevertheless, other applications in the e-health domain or other domains may benefit from this system to optimally deliver a notification while drastically improving the efficiency and impact of the notified information for the end-user. In a more service provider perspective, application designers can take benefit of this new communication infrastructure by creating more ambitious scenarios, saving development costs and gaining effectiveness and abstraction concerning the user's reachability concerns. Such technology will therefore contribute to offer both improved quality of life to citizens and a more cost-effective and efficient solution for service providers.

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