An Open Platform to Support Home Healthcare Services using Interactive TV

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Abstract— **This paper presents an open platform to support the development and deployment of healthcare services at home using the TV as the main gateway. Unlike previous systems based on proprietary and closed solutions, our proposal is completely open allowing the easy integration of new services or the integration with external platforms. This is possible thanks to the use of a PC-based Set Top Box called Home Theater Personal (HTPC) that can be easily connected to the TV and Internet. This solution is not tight to particular Software and Hardware providers. It allows an easy integration of different telemedicine devices through Bluetooth and USB standard protocols. Additionally, any software developer/provider can include new services and healthcare modules through a simple to use add/on platform.**

I. Introduction

Along the last years the number of dependent individuals requiring access to new ICT services is increasing [1]. These users, that include people with disabilities and elders, has a higher rate of chronic diseases and other conditions that hinder their interaction capabilities and require continuing monitoring and attention. The provision of adequate ICT services may dramatically improve the quality of life of these users [2]. Besides, new technologies, and more specifically software and hardware solutions to improve healthcare and provide online attention, may also contribute to reduce the costs of these services [3].

One of the main advantages of these technologies is their support to the continuing monitoring of individuals at their own homes. This reduces the need to visit health care centers and contributes to improve the diagnosis and follow-up of biomedical parameters from a centralized health facility.

In general, tele-monitoring and tele-assistance solutions implemented are based on the deployment at patients' premises of specific applications and devices to collect information (e.g., biomedical parameters) to be sent to a health center and back. Besides, these solutions are closed proprietary applications and devices [4] that make their adaptation to the specific needs of a given patient very difficult or even impossible.

New technologies are enabling a great development and advancement in the field of telemedicine. We can find many different systems and platforms providing specific remote medical and welfare services. These systems are based in most cases on proprietary solutions designed to solve some specific problems related to specific the medical care process and specific patient situations. In other words, they are closed solutions that make it practically impossible to extend their functionality to other medical areas or patient profiles for which they were not originally designed.

Thus, if a given patient needs constant monitoring for a new biomedical variable for which the system he or she has at home is not ready, this patient has no choice but to acquire a new system with this capability. This will increase the costs and complexity associated to address new health care situations.

From this point, the user needs to acquire the skills and abilities required to interact with the new system deployed at home. Besides, in most cases the introduction of the second system will not eliminate the need of other systems already deployed. Each of the systems is ready for monitoring and tracking certain parameters and vital signs, so in most occasions both systems will be necessary. This not only increments the final cost of an integral health care solution, but it also increases the cost in terms of complexity of understanding of the new solution. It is no longer enough for the patient to operate and control of a single system, but he or she needs to make an additional effort to learn the control and operation of a second system that may be from a different manufacturer, and therefore exhibiting totally different operation modes.

There is a specific group of dependent users that poses additional challenges when deploying ICT-based health care equipment, namely elder users. Aged people have specific physical and psychical characteristics that directly influence their ability to interact with technological devices deployed at their homes. In turn, this will influence their perception on the benefits of technological advances, as their personal characteristics will condition the perceived usability of the aforementioned solutions.

Besides, these individuals spent most of their active lives in a time when technology did not permeate the complete society as it happens today. As a consequence, differently to present-day adults and young adults, they did not have a close relationship with technology, which makes them to reject technological advances, in many cases just because they do not understand them.

Thus, developing technological solutions in a way that dependent people will perceive them as something familiar, useful and simple to operate is a real challenge. Addressing this challenge will also require to adapt the processes associated to health care provision to the specific needs of each individual or group of individuals experiencing similar support needs.

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This paper introduces a new approach to the provision of assistance and health care services using the TV set at home as the central interaction and communication device, as the TV set is the most widely known technological device, and it is present in most households in developed countries. First, we discuss the different approaches available to provide interactivity through the TV set. Then, we introduce the platform developed and discuss its pilot testing with real users. Finally, we present some concluding remarks.

II. The TV as the Gateway for Home Healthcare Systems

In technological and temporal terms, societies in industrialized countries can be divided into two distinct groups that some authors define as digital natives and digital immigrants, a definition that in turn highlights a key difference between these two groups. While some individuals were born in a digital era where technical developments are common and a constant adaptation to new designs and solutions is required, others were born in an analog era dominated mainly by television, radio and telephone. For this second group of users, the rate of technological adaptation imposed by the new era is hard to follow.

Aged citizens, and to some extent people with disabilities, are among the second group. The elder were born in a fully analog era, and the shift to a digital paradigm occurred at an advanced age and no possibility was offered to these users to actively live (through work, education, etc.) with new technologies around them. On the other side, people with disabilities experience in many cases the same situation of lack of opportunities to interact with new technologies to facilitate their integration in the digital society.

It is therefore essential to identify the instrument that will facilitate the transition to the digital world for these groups. It has to be a familiar solution, something that will not generate a sense of rejection even when acknowledging the promised benefits of new technologies.

In this context, perhaps the better known and most widely accepted technological solution is television. The TV set is present in almost every home in developed countries, and it has maintained its core functionality no matter technical progress and technological advances. However, TV sets are still fully passive devices through which users can access content sent via a broadcast signal. Specific content is selected through a remote control whose basic functionality practically has not evolved with time, and with which most users feel comfortable.

However, its inception as a passive device makes it difficult to adapt it to become the basic interaction device with a portfolio of health services. Thus, it is essential to provide the required active elements for the user to interact with it and therefore to be able to access the portfolio of services.

With the advancement of ICT, initiatives have emerged in relation to the provision of interactive TV solutions. A common element of these approaches is the provision of a return channel [5] through which information can be transmitted from the user's home to a central premise or other users. An example of this quest for TV interactivity is the Multimedia Home Platform (MHP) [5] standard, which in most cases has had little impact on the market to eventually become a totally obsolete solution. Most probably, the main reason for this failure was not technical but strategic or commercial. Receptors for Interactive Digital Television (DVB) that integrated support for MHP were expensive and had some limitations in terms of programming capabilities, so sales were low. In addition to this, the main DVB operators did not promote the standards through popular services.

Failures such as the MHP case discussed above have motivated us to search for other devices already in the market as well as solutions based on mature technologies as far as possible. For this, other solutions like HBBTV [6] were directly discarded.

With the rise of digital terrestrial television and the need to decode the digital signal to make it compatible with legacy analog TV equipment, a new kind of device named set-top box (STB) appeared [2]. These devices have premium image processing capabilities for signal decoding. Moreover, they have open characteristics that will eventually support full integration with external devices as well as the development of new services and applications on them. The availability of STB with open source operating systems like Linux in principle opens new horizons with respect to the ability to extend their functionality to develop complex digital systems. However, the STB's underlying hardware severely limits the development of new services and applications. Note that, when compared with a mainstream PC platform, STBs are not versatile enough to support a solution as the one proposed in this work.

III. Our Open Proposal

The introduction of services offering multimedia content served directly from the Internet, led to the emergence of new devices named Home Theater Personal Computers (HTPC) [7]. Their network connectivity features, low noise characteristics and interfacing options based on standards supporting direct connection to a TV set as HDMI, made them to become a good choice to consume Internet content to be displayed on the home screen. However, insofar the pursued solution is concerned; their main advantage lies in their very internal architecture.

The HTPC's Personal Computer architecture facilitates the connection to a multitude of external peripherals [8] (e.g., webcams, gesture controlled remotes like the Nintendo's Wiimote, or Microsoft's Kinect, etc.) thereby opening the range of possibilities in terms of new control devices to other external devices that support tasks such as autonomous decision to transmit information through the network. Similarly, the HTPC approach enables the use of virtually any programming language as well as a multitude of programming libraries for practically any ancillary feature. This will reduce development time and effort, which in turn

will dramatically reduce the final cost of the proposed system.

As a result of this architecture, it is possible to integrate any operating system suitable to support the logic of the pursued platform. According to the objectives of our solution, such as its low cost or open architecture, a version of the Linux operating system has been selected. One of the main applications of HTPC platforms that will eventually serve as a basis to provide health-related multimedia services is home entertainment by enabling access to multimedia content on the TV set. In our case, we integrated the open-source XBMC Media Center [9]. Finally, the solution proposed in this paper follows a SOA [10] (Service Oriented Architecture) distributed services architecture based on web services. With this, an effective decoupling between the data model and business logic is achieved, as well as the decoupling of the sub-systems that make up the final solution.

The versatility offered by the integration of a HTCP makes it possible the use of multiple communication interfaces (e.g., WiFi, Bluetooth, IR, etc.) and therefore the ability to interact with many different control devices. Thus, the an HTPC-based solution can respond to different adapted devices and controls (e.g., joystics, adapted keyboards, gesture controlled remotes).

IV. Home Healthcare Services

The proposed platform integrates both third-party services and some services specifically devoted for this solution. For example, a module was developed to monitor monitoring vital signs, blood pressure among others [11]. Through this service, the patient can carry out a blood pressure measurement at home (cf. Figure 1). All measures will be sent to the control center to be stored and subsequently analyzed by medical personnel.

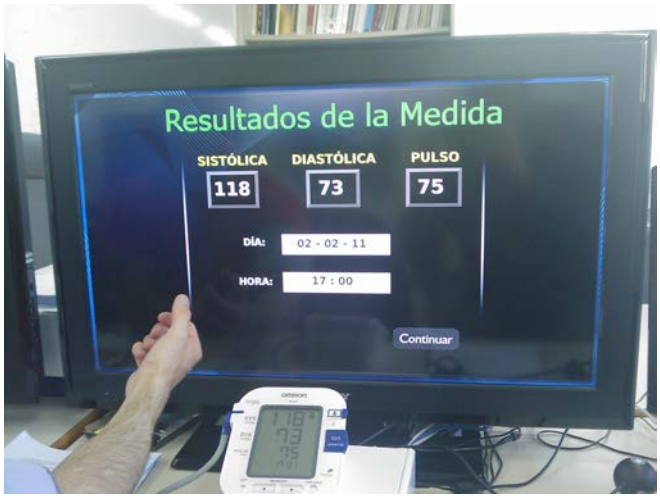

Figure. 1 Blood pressure measurement

Another feature is the provision of on-demand rehabilitation multimedia content (cf. Figure 2) intended to allow patients to track their particular rehabilitation activities. Through a collection of categorized videos a user can access rehabilitation multimedia support in an easy and simple way from its own TV. The selected video is displayed full screen on the TV screen.

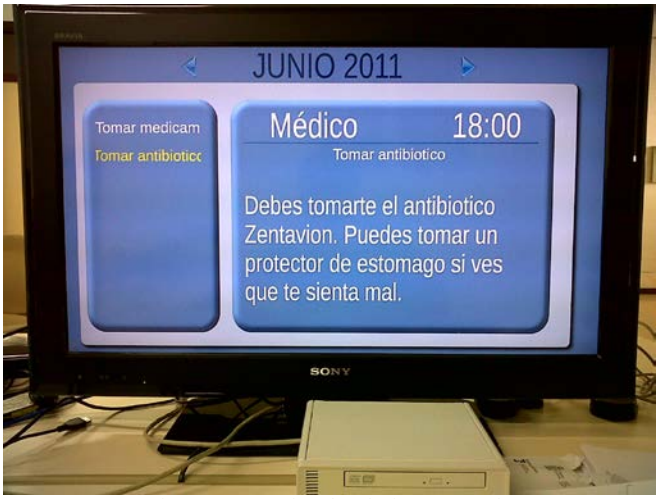

Figure. 2 Accessing the platform's agenda

The developed platform also provides access to a calendar of events and a notifications service. Through this service, the patient can access anytime the nearest medical events and notifications (cf. Figure 3), including planned doctor visits, medication intake reminders or the schedule to perform certain rehabilitation exercises. While the user can access a calendar where all of these events are shown, the system will notify the user upcoming events on the TV screen.

Figure. 3 Accessing rehabilitation videos

V. Validation

Due to space limitations, we will make a brief description of the pilot phase conducted with real users, which will be further presented at the conference. To validate the system three pilot test sessions with real users were performed. In each of these sessions different features of the developed platform were tested. Besides, an incremental approach was followed based on iterations. During each of the testing sessions, user feedback was captured by means of perception

surveys performed both before and after interaction with the platform along several days.

The first two pilot tests were conducted with a small number of users to keep the number of expected incidences limited and to be able to adequately respond to unforeseen failures, whether these could be solved remotely as if they require an expert or technician to move to the participating users' premises for correction. The third pilot test (cf. Figure 4) was carried out with a total of 62 users spread in the autonomous community of Galicia (Spain). This final test included only users older than 65 years old. The same survey was performed in this case (i.e., prior and after several days of platform usage).

From the data collected, all respondents but one said that the HTPC-TV set combination is a lot easier for them to use than a mainstream PC, and even 82% of respondents said they prefer to access online services through the platform developed better than using a networked personal computer.

Figure. 4 User participating in the pilot testing phase at home

VI. CONCLUSION

While the learning of new technologies or the acquisition of skills to utilize state-of-the art technological devices may have a lesser impact on young or young adults, in the case of aged individuals or people with disabilities, this impact may be critical. The development of this platform has shown that, when interacting with systems and services in the digital world, this kind of users react better and show a milder rejection attitude towards a familiar device like the TV set. Besides, the proposed solution integrates an adapted control interface according to the characteristics of the TV set, with further enhances the perception of familiarity and confidence. Indeed, the lack of training sessions during the pilot-testing phase was no impediment for the users to access by themselves to each and every of the services offered by the platform.

The services offered may be dynamically extended through the inclusion of third-party or new services. Having a common access interface makes dependent people to feel safer when interacting with the new services without needing any training phase.

On the other hand, in many cases tele-assistance is perceived as a quasi-passive mechanism through which a control center receives the information of the registered user only when users encounter some type of previously defined problem or situation. Through this experience, and according to the data collected, we perceived a willingness of users to be active in their recovery. For example, activity logs showed that rehabilitation videos, including both cognitive and motor rehabilitation multimedia content, were among the most popular features of the platform.

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