Improving the Quality of Life of Dependent and Disabled People through Home Automation and Tele-assistance

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Abstract— **Lack of mobility in certain groups of dependents forces them to spend a lot of time at home. In many cases, this limitation makes these people to stay most of the time in a specific room in their houses such as the bedroom or living room, where the only means of entertainment and information gathering is the TV set. Most of present-day households have a personal computer, but the digital divide and lack of adaptation produces certain rejection in this population group. This paper discusses a proposal that leverages the familiar TV set to be used as the user interface for a complete tele-assistance system and control centre of home automation devices. For this, the system makes use of a Home Theatre Personal Computer (HTPC) connected to the TV and offers the features like the monitoring and remote monitoring of a wide range of vital signs, intelligent adaptation of services and interfaces according to the level and type of disability, and centralized control of home automation devices installed at home.**

Keywords— e-Health; HTPC; TV; teleassistance; home automation.

I. INTRODUCTION

In industrialized countries, care provision to dependent individuals is becoming a priority. The increase in the quality of life fosters an increase in life expectancy, and therefore their longevity [1]. As a consequence, it is a major challenge for industrialized countries to maintain the quality of life of these groups, and to adapt health policies to the new population demographics.

One of the aspects that is getting special attention to tackle this problem is the application of new technologies adapted to improve the quality of life of these groups. Systems and platforms proliferate in the quest for novel technological solutions are numerous, in most cases providing services for the care and the improvement of the quality of life of these individuals [2], [3].

While all of these platforms have advantages and benefits for the target population's everyday lives, in many cases users are sceptical or even reject new technological systems, mainly because they feel unprepared for understanding their behaviour, and therefore to adequately interact with them.

This paper introduces an open source platform that provides a complete tele-assistance and home automation control system of through a simple and familiar user interface as the TV set. Relying on this interface allows target user groups, especially the elderly, to overcome their initial reluctance to use new technologies. TV becomes the user interface, and through it all interaction between the user and the platform takes place.

To provide the needed interactivity on a TV-based platform we rely on a home theatre PC (HTPC). Thanks to its PC architecture, the platform has the required modularity and processing power to provide the services implemented. Besides, the PC architecture facilitates the integration of new communication interfaces to support the communication with home automation devices or devices intended to monitor biomedical parameters.

Among the services offered by this platform are medical services, such as the monitoring of vital signs, rehabilitation games, educational videos providing information on a wide range of diseases or disabilities and videos with rehabilitation exercises; social services such as medication reminders and alarms and access to social networks like Facebook or Twitter; and home automation services, through which any home automation device may be controlled from the TV set.

The heterogeneity of this proposal's target population and the particular needs of individual users require paying special attention to user interfaces. Our platform's user interfaces are automatically and transparently tailored to the specific needs of the individual accessing the system. To achieve this, the platform implements an automatic adaptation layer for the user interfaces and services offered, which simplifies the usage and control of the system by taking into account the particular characteristics and needs of the user.

Along the rest of the paper we will discuss the most relevant elements of the proposed solution. Section II briefly introduces the general aspects of the platform. Then, Section III describes the medical parameter's monitoring system, and Section IV discusses the home automation control system. Finally, we will outline the main conclusions drawn from this research in Section V.

II. TELE-ASSISTANCE PLATFORM

As stated above, the main objective of this proposal is to create a platform for tele-assistance and home automation

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control through a familiar device as the home TV. Thus, the television will become the control centre of all remote assistance services provided, and of all home automation devices in the user's home.

The use of television as a user interface minimizes the initial rejection to the use of new technologies by some groups of dependent individuals. Rendering information and services through a familiar and easy to use device as the TV set, simplifies learning and therefore access to services and information. For example, most users are accustomed to interact with the TV via the classical TV remote. Therefore, the TV remote no longer becomes a new device but a familiar one, which fosters an early adaptation to the new platform, and the perception of new services as extensions of the functionality of the TV instead of perceiving them as new services they have to learn to use.

The design and architecture of the TV set is corresponds to a completely passive device, in which the user is a mere spectator of the contents displayed by the screen. To provide the TV with the required interaction capabilities, our proposal is based on an HTPC connected to the TV, which will provide the necessary interaction features, a high degree of modularity, and support for interconnecting additional peripheral devices, both wired and wireless. Through this low cost PC, users can access the full potential offered by state-of-the-art Internet services, applications and platforms just by changing the TV channel. The final system is fully modular and extensible, and supports the adaptation and integration of the functionalities offered according to the type and degree of dependence of final users.

The need to adapt the platform to different user needs, doesn't affect graphical interfaces. This platform goes a step further, and based on the ability of HTPC for integrating different communication protocols, we defined new adapted control mechanisms. The appearance on the market of devices that integrate gyroscopes and accelerometers that can detect movements, as like Nintendo's WiiMote [5] offers new possibilities for motion-based user interaction. This remote control device can be connected to the HTPC via the common Bluetooth. Therefore, besides the classic control through push buttons, control can be performed via the detection of movements performed by the user. This form of adaptive control, allows on the one hand a reduction in the number of buttons required in the remote control and therefore in control complexity. On the other hand, users who have some limitations [6] in the use of conventional remote controls can access and interact with the platform through motion detection.

The simplicity of the interconnection with external devices also enables the incorporation of a broad range of vital sign measurement devices. Besides, the HTPC's PC architecture supports the development of specific communication interfaces to virtually all monitoring devices currently on the market. Thus, the proposed platform becomes an extensible system that can be easily adapted to incorporate new measurement and patient monitoring solutions, together with other systems such as smart card readers, home automation systems, etc.

All data collected in the HTPC are sent over an Internet connection to the control centre. The platform is designed around a client-server Service Oriented Architecture (SOA, [11]). The platform makes use of distributed network services both to transmit and receive information. Storing data remotely allows users to access their accounts from any deployed home platform. There is no need to manually customize client platforms, but the platform automatically personalizes interfaces and services once the user is identified.

Besides, having data stored remotely presents some advantages, but also requires special attention to protect the transmission of information. Many of the transmitted data will be of medical nature, and therefore very sensitive to the data protection laws in many countries (e.g., Spain's Data Protection Act). All sensitive data will be transmitted via an SSL-encrypted secure communications channel from the client computer and the central server.

From the users' point of view, the management and transmission of information is a completely transparent process. A software module based on the XBMC media centre [10] will be responsible for performing each of the required actions on behalf of the user. XBMC is licensed under GNU / GPL, and has been modified to add new functionality to the native functionality of a media centre, which is focused on multimedia playback and graphic event management.

Among the new features are the management of the specific communications services developed for this platform. For this, we relay on the standard Extensible Messaging and Presence Protocol (XMPP), which has been integrated within the platform. A central messaging server based on OpenFire performs the routing tasks for the information transmitted by each of the services to their intended recipient. The integration of the XMPP protocol for the exchange of information supports the enrichment of the messages transmitted and their customization for each of the services implemented. The XMPP protocol relies on the exchange of XML files. These XML files follow a common base structure that can be easily extended with new labels to represent any messaging requirement. Thus, services may add new fields with the required information to the messages conveyed, where only the corresponding service is able to capture and understand the information transmitted.

XMPP's presence control support enables the platform to be continuously aware of the state of each user. When users access the system or simply change their state, an associated event is collected by the communications server and transmitted to all users or services that are authorized to detect changes in their status. For example, with this functionality a service may detect when a given user is accessing a specific service, and therefore it will be able to establish a synchronization mechanism to send the required information.

III. MEASUREMENT OF BIOMEDICAL PARAMETERS

Tele-monitoring care systems are among the ones most benefiting of technological progress. Monitoring has become a basic functionality in a tele-assistance platform, and many

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state-of-the-art tele-assistance platforms include functionality for monitoring and measuring several biomedical parameters.

The application of information and communication technologies to home monitoring provides a great capacity for gathering and transmitting information, which in turn enables a more complete and continuous monitoring of patient evolution, and therefore enhances the ability of health professionals to perform a better analysis and diagnosis of patients' situations.

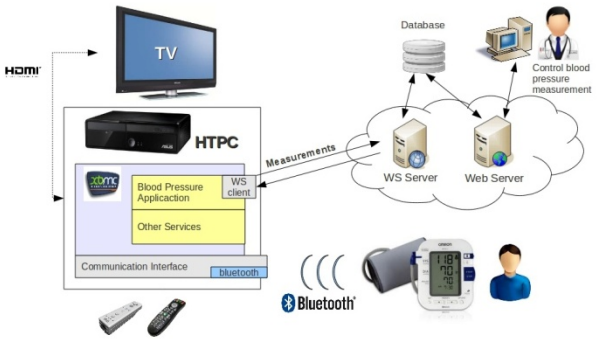

Fig. 1: Remote blood pressure control

The flexibility and extensibility provided by the HTPC architecture allows the integration of the vast majority of devices for the measurement and analysis of biomedical parameters in the market, and even the integration of any custom-made device. In our case, the HTPC serves as a communications gateway between measurement sensors and the data centre (cf. Fig. 1). Besides, the availability of both wired and wireless communication interfaces facilitates the adaptation to almost any sensor available.

A. *Measuring Biomedical Parameters*

All measurements are made at patients' premises to be automatically sent to the data centre through the residential gateway. To perform a measurement, the platform implements two modes, namely on-demand and remote warning.

By operating on-demand, the system acts as a passive device where users take the initiative to carry out a particular action. For example, for a blood pressure measurement performed under this mode of operation, users will navigate through the service menus to select blood pressure monitoring. Once the sphygmomanometer takes the measurement, values are transmitted to the wireless communication gateway. The residential gateway performs some error checking and connects to the biomedical parameters' storage server to transmit the measurement results.

The transmission of the blood pressure measurement taken at the patient's home is performed via the SOAP protocol. An instantiation of a Tomcat Web server performs all necessary operations related to authentication and communication with the residential gateway. As this service manages personal and medical data, users have to authenticate at the residential gateway to access the blood pressure measurement service. Two authentication modes have been implemented respectively based on a username and password pair, and on a smart card. Smart card authentication no longer requires users to remember complex passwords, as authentication is performed through the credentials stored in the personal smart card inserted into a smart card reader.

When the user inserts the smart card into the reader, the residential gateway reads the credentials stored in the card and establishes a communication through a Web Service with central user management server. The server will check the authenticity of the credentials submitted and will generate a session token, which will be returned to the residential gateway. From this moment on, this session token will be used for all transfers made from the patient's home to the medical data servers. In this case, the duration of the session is determined by the state of the smart card reader. If the reader detects the card removal or the disconnection of the reader, it will automatically disconnect the user and therefore deny any access to services handling private information such as biomedical parameters' measurement services.

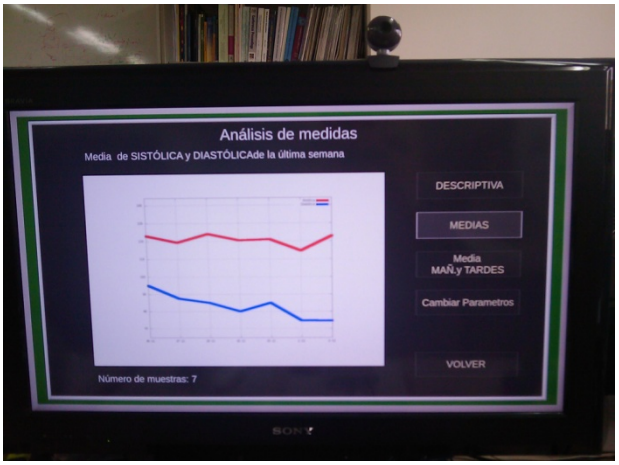

Fig. 2: PA analysis

In the remote warning mode, the platform notifies the user and executes the appropriate actions on the user's behalf. A message on the TV screen warns the user about a pending measurement of some biomedical parameter. The user just acknowledges the message by pressing an OK button on the interface to run the corresponding service. After the measurement, the process continues in the same way as in the case of an on-demand measurement. Obviously, this operation mode is valid only for users who are already authenticated by the platform.

Figure 2 below illustrates a blood pressure analysis performed at the patient's premises.

B. *Access to remotely stored data*

All biomedical data are stored remotely in the data centre to be accessed by authorized medical staff. Medical staff

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may use any Web browser to access the information of any of their patients (cf. Fig. 3). When doctors access the web platform they are prompted for a username and password. Once they are authenticated, a list with all their patients is displayed. Using this web tool, doctors may access the historical measurements performed by any of their patients, which in turn improves the diagnosis and treatment processes.

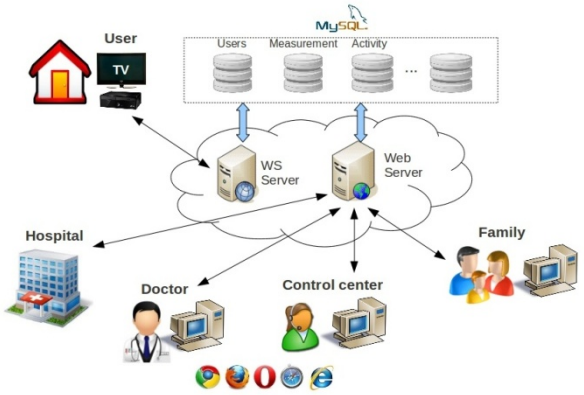

Fig. 3: Access to patients' information

Once the data have been analysed by the medical staff, they may schedule new measurements or update the instructions given to patients. They may also schedule new remote-mode measurements, which will be notified to patients the next time they are authenticated on the platform.

IV. HOME AUTOMATION SYSTEM

In recent years we are experiencing and ever increasing impact of home automation on our lives. This is a particularly interesting field for dependent people, as many tasks they cannot perform, may be performed when assisted by home automation devices installed at home. A task as simple as turning on and off of the lights can be a very difficult task to be performed by a person with certain physical disabilities, or even impossible for a bedridden person. Thus, home automation has great development potential for these population groups.

In many occasions, the simplicity of certain tasks when performed through home automation devices contrasts with the excessive complexity of the controls of these devices, and the need to have different controls to cover all brands of home devices installed in a home.

Although we can find in the market several communication protocols and control systems for home automation, manufacturers use to provide their own custom solutions, so that the integration in a single installation of devices from different manufacturers becomes a difficult task in many cases. To overcome this situation, the platform discussed in this paper acts as a middleware for different home automation systems installed in the user's home. For this, the residential gateway integrates into a single device all the communication protocols needed to interact with products from different vendors. As discussed above, the use of a HTPC as the hardware platform provides the required flexibility to integrate all those different wired and wireless communication interfaces (Fig. 4).

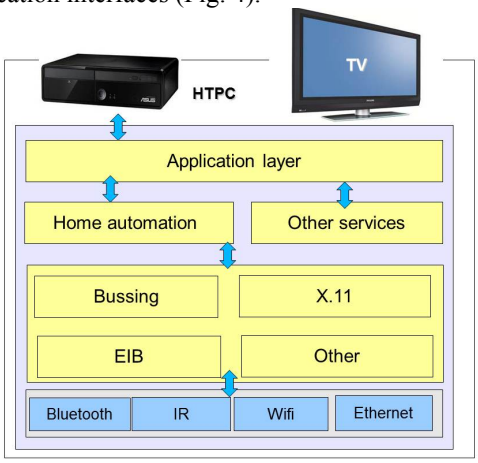

Fig. 4: Home automation architecture

By selecting the appropriate interface, information can be routed to each specific home automation device, and the TV set becomes the control centre of the complete home automation infrastructure. Users may send commands to perform the desired actions through their customized graphical user interface, which will be automatically and transparently routed to one or several physical devices. We describe below the operating mode of a particular home automation protocol, namely the Busing protocol. This example can be extrapolated to other home automation protocols installed at the user's premises.

A. Busing Protocol

This is a proprietary home automation communication protocol. The Busing system uses a four-wire bus for transmitting information among devices. Each home automation device is connected to the bus, having a unique identification number. Commands are transmitted to a data bus together with a unique identifier representing the destination device. Then, the destination device will capture the transmitted information and execute the action associated with the command. All information sent to the bus is packed into data frames, and these frames are transmitted by a specific device called ETHBus. This device has an Ethernet interface and a proprietary Busing interface, so the ETHBus behaves as an Ethernet-Busing bridge.

The proposed tele-assistance and home automation platform connects to the home automation network through an ETHBus connected to the HTPC's Ethernet interface. Users' TV screen interactions are translated into Busing commands to the appropriate devices and sent to the home automation bus for execution. When an order is executed or the home automation system detects a change (e.g., the presence of a person in a surveyed area) it sends that information to the bus to be detected by the ETHBUS, which will convert the data package into an Ethernet frame to be sent to the HTPC. Eventually, this information will be

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conditioned to be presented to the user as a notification or alarm displayed on the TV screen.

The control of electrical and electronic devices is performed via a 6E6S device. This device consists of 6 on-off relays. Each of these relays may control an electric appliance, and they may be enabled and disabled manually or automatically.

Manual activation is performed through each of the six input gates in the 6E6S device. These terminals may be connected to on-off buttons or switches that the user may operate manually. Automatic activation and deactivation is performed through the transmission of Busing commands as discussed above.

Although this device may present a very basic functionality, it is one of the most used devices in present-day smart home installations. Simple on/off actuations may cover a broad range of electrical and mechanical operations, such as opening and closing motorized window blinds, switching lights on an off, opening and closing windows, doors and gates, etc.

In addition to sending commands to smart home infrastructure, the platform also has the ability to receive and process data sent by other devices such as motion detectors. These devices are placed in the user's home to detect movement in any room. They use infrared beams to detect notify presence in their range of detection, and when the remote assistance platform detects motion in any of the areas of the house where motion detection is installed, a notification is displayed on the TV. While these devices are typically used for motion detection in certain areas of the house, such as the front door, they may also be combined with advanced algorithms to detect specific user behaviours, and therefore to detect abnormal situations that may occur at home, or even the lack of activity.

As with other platform services, user access to home automation control requires authentication. Once the user has been identified, the user interface displays all installed automated systems in the house making transparent their types and models. Thus, home automation systems are integrated and centralized at the TV set (cf. Fig. 4).

V. CONCLUSIONS

Industrialized countries are facing demanding situations in relation to care providing to dependent and disabled individuals. Population ageing and the inversion of the population pyramid are leading many governments to rethink their current welfare systems. More and more resources are needed to fund the required welfare policies aimed at these groups of people. This is one of the reasons why tele-assistance and the introduction of ICT at home are seen as a promising way to tackle a problem that is relevant at a greater or lesser extent to all industrialized countries.

This paper proposes a low cost and open I tele-assistance solution based on the HTPC hardware architecture connected to the TV. This approach allows an easy integration of novel tele-assistance system and the centralization in a single device of all home control and remote assistance systems installed in the user's premises.

The fact that a large number of dependent and disabled people spend much of their time alone at home makes the TV set to become their only method of entertainment, and therefore the only option to interact with other people. The ubiquity of the TV leads us to think about this appliance as a perfect medium to access not only to conventional television programmes, but also to a service portfolio that may dramatically increase their life quality.

Our system aims to facilitate typical tele-assistance services such as the monitoring of different biometrical parameters, and the user-friendly control of home automation devices. The possibility to integrate a comprehensive home automation system in a totally transparent way makes this to be seen as a simple and easy to use solution, avoiding the initial rejection attitude common in certain groups of dependent people, especially our elders.

Using the TV as the unifying centre for ICT services as well as reducing the initial rejection to new technologies, also influences deployment costs. Virtually all households in industrialized countries have at least one TV set, so the acquisition costs will be dramatically reduced. On the other hand, the HTPC's modular architecture and its peripheral interconnection capabilities make this platform easy to extend and adaptable to the needs of each individual user.

Finally, we would like to note that the open nature of most of this platform's components facilitates the integration of third-party developments to increase the functionalities provided.

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REFERENCES

[1] (2010) World Health Organization. [Online] Available: http://who.int [retrieved: 11, 2012].

[2] O. Onyimadu, F. Harding, J Briggs,"Designing a telecare product for eledery", 5th International Conference on Pervasive Computing Technologies for Healthcare, Newbury , May 2011, pp. 336 – 339

[3] (2012) Philips Motiva [Online] Available: http://www.healthcare.philips.com/es_es/products/telehealth/Products/motiva.wpd [retrieved: 11, 2012]

[4] A. Tesanovic, G.Manev, M. Pechenizkiy, E. Vasilyeva, "eHealth personalization in the next generation RPM systems", 2009 22nd IEEE International Symposium on Computer-Based Medical Systems, pp.1-8, Aug. 2009, doi:10.1109/CBMS.2009.5255383

[5] F. Iacopetti, L. Fanucci, R. Roncella, D. Giusti, A. Scebba, "Game Console Controller Interface for People with Disability", International Conference on Complex, Intelligent and Software Intensive Systems, 2008, pp.757-762

[6] Y.-J. Chen, "Using real-time acceleration data for exercise movement training with a decision tree approach", 2009 International

 ISBN: 978-1-61208-256-1

Conference on Machine Learning and Cybernetics", doi:10.1109/ICMLC.2009.5212632, July 2009, pp. 3005-3010.

[7] (2012) OpenTV [Online] Available: http://opentv.com/ [retrieved: 11, 2012]

[8] (2012) MHP [Online] Available www.mhp.org/ [retrieved: 11, 2012]

[9] E.J.W. Van Someren, "Actigraphic monitoring of movement and rest-activity rhythms in aging, Alzheimer's disease, and Parkinson's disease", IEEE Transactions on Rehabilitation Engineering, vol. 5, pp.394-398, doi:10.1109/86.650297

[10] (2012)The XBMC website. [Online]. Available:http://www.xbmc.org [retrieved: 11, 2012]

[11] L. White et al., "Understanding interoperable systems: Challenges for de maintance of SOA applications", Conference on system science (HICSS), Hawaii, january 2012, pp. 2199 – 2206

[12] B. Xuefu, and Y. Ming, "Design and implementation of web instant Message System based on XMPP", 3rd International conference on software engineering and service science (ICSESS), Dalian, June 2012, pp. 83-84.

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