Providing In-house Support to Disabled People Through Interactive Television

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***Abstract* — We introduce a low-cost open platform to provide services targeted to disabled people and their families. This system is deployed using mainstream consumer electronics equipment and is specifically designed to provide services at home. The proposal goes beyond state-of-the-art tele-assistance to implement the broader concept of socio-sanitary care. Thus, the final objective of this platform is to assist disabled people having specific care necessities, but considering, at the same time, their social integration and their quality of life. This is achieved through a wide range of services that are dynamically adapted to users' specific conditions and environments. The proposed solution significantly improves the quality of life at home of disabled people.**

Keywords – Teleassistance; socio-sanitary care; eHealth; disabled people; interactive television.

I. INTRODUCTION

In the past years, improvements in quality of life and life expectancy [1] and advances in Information Technologies have fostered the deployment of solutions targeted to disabled and elder people. Indeed, society urgently demands tele-assistance systems to address the needs of this population sector, to facilitate their integration and, eventually, to develop an efficient socio-sanitary system adapted to the present-day demographical and social situation. The term *tele-assistance* [2] refers to a wide range of systems used to provide remote care to old and/or physically challenged people to facilitate living in their own homes.

This paper discusses the development of a service platform that deals with a new way of understanding tele-assistance that also considers solutions to provide challenged and elder people better ways to become more integrated in society, to communicate with their families and caretakers, and to attend all their specific needs. Potential users of this platform are elderly and/or disabled people who are in a care-dependence situation. Because of the characteristics of its potential users, the system has been designed to be simple to use and adaptable to specific physiological user needs.

A standard TV set was selected as the presentation and users' interaction device. This decision was based on several reasons, including the existence of a TV set in most if not all potential users' homes, which contributes to stress the low-cost design principle and to limit users' reluctance due to the introduction of a new technological system into their daily routines. Other relevant reason for this choice is that elderly and handicapped people are usually quite familiarized with a TV set's mode of operation, which contributes to reduce adaptation and learning time.

A further aspect taken into account when designing the system was the present-day economic scene and the average financial capabilities of this population sector. For this, we tried to keep implementation and deployment costs as reduced as possible.

In order to design the most suitable architecture and software platform, we made an exhaustive analysis of several technologies. After this analysis, we selected a Linux-based Home Theater PC (HTPC) [3] as the main component at home connected to a standard TV set, complemented with an open-source media center solution,. This architecture was chosen because of its availability, its limited cost, and its support to the seamless integration of interactive services and the Internet, fulfilling all initial system requirements, namely low-cost, acceptance by potential users, modular structure enabling service personalization, reusability and extensibility.

Regarding communications, the platform captures all relevant data from users and sends it through the Internet to a central server, which is also accessible through a web-based management interface. Since users utilize the TV set and a common interface to access the provided platform services, they are configured and deployed using a common remote management platform. To increase the range of users, the system integrates additional interfaces to facilitate service access to a wide range of physically challenged users.

To sum up, the potential users of this innovative platform are elderly people or people with some kind of disability, who in most of the cases are in dependence situation. Users are provided with access to a wide range of socio-sanitary services through a low-cost, open, adaptable and extensible platform.

Section II introduces the proposed system's architecture, that is, the technical framework adopted when designing and integrating the various hardware and software components. Section III is devoted to discuss the selected service provision mechanisms and standards. Section IV discusses additional details on interface design, as this topic is instrumental to provide an adequate solution to our target audience. Finally, Section V collects the most relevant conclusions of this work.

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II. SYSTEM ARCHITECTURE

In the next paragraph, we discuss the components that configure our service platform and their interactions. Figure 1 outlines the basic structure of the platform.

A. User Hardware Platform

To provide the TV set with the desired interactivity, several hardware devices were considered during the design phase. Among them, those that could be easily integrated in a living-room atmosphere were taken into account. Initially, game platforms were considered due to their low price, ease of use, wide acceptation, and the availability of next-generation interfaces like Nintendo WiiMote or Sony Kinect [4][5]. However, they were discarded because of the difficulties faced when trying to integrate off-the-shelf and open components or specifically designed interface devices for physically challenged people.

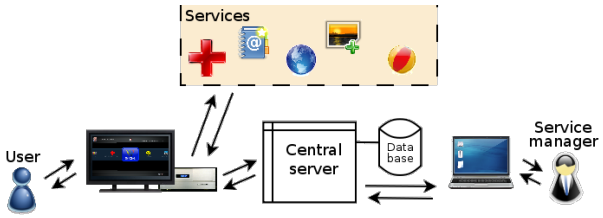

Figure 1. System Architecture outline

Other devices considered were intelligent set-top boxes (STB) [6], that is, devices whose primary purpose is the reception and decoding of multimedia signals to be displayed in a TV set. Every state-of-the-art STB includes some kind of middleware that supports the development of hardware- and software- independent applications. However, this class of systems was also discarded due to the complexity of the software development tools available and their limited support for general-purpose software applications.

The device eventually selected to be part of the final system is the Home Theater PC or HTPC, which is a personal computer specifically designed to be used as a multimedia reproduction device at home, using a standard TV set as the display unit. These devices can be defined as small full-fledged personal computers that give up processing power in favor of a noiseless, small and attractive system design. The main advantage of HTPC regarding our goals is their PC architecture, which supports system's extensibility through widely available standard interfaces. Besides, any conventional operating system may be installed in an HTPC, which contributes to facilitate its extensibility through new applications, and they provide native support for remote control devices. When compared to other solutions, HTPC provide more features at the same cost, higher connectivity, and a more complete and accessible software development environment. In addition, advanced interfacing devices like Microsoft Kinect for Xbox or Nintendo WiiMote could also be supported by the final system taking advantage of the HTPC's personal computer architecture.

B. User Software Platform

The software platform is based on an open source Linux distribution. This choice was made due to its usability, and the free, low-cost and open source orientation of the final system.

Since final users will operate the HTPC using a typical TV remote, we also introduced a media center to enable full interactivity between the remote interfaces and HTPC content. Four media center solutions were examined to choose the most suitable one fulfilling the requirements of the final system, namely MythTV, Moovida, LinuxMCE and Xbox Media Center (XBMC).

Moovida was dismissed due to its lack of maturity and the absence of a TV watching functionality or a back-end, and LinuxMCE was ruled out because of its complexity. Thus, the final choice was made between XBMC and MythTV. These are very similar systems, MythTV having outstanding TV functionalities and XBMC having greater extensibility. Taking this into account, and due to the fact that one of the main features of the final system should be its extensibility, XBMC was the final selection. XBMC supports extensibility through two mechanisms, namely plugins and scripts. Plugins are used exclusively to add new multimedia sources to the media center, while scripts allow the addition additional functionalities. Both MythTV and XBMC are supported by a large community of developers, and provide a comprehensive and clearly organized documentation, but XBMC provides an easy to use programming interface for developing new services written in Python [7], and has an intuitive and user-friendly user interface. Unlike MythTV, XBMC doesn't provide any Internet browser or a native feature to watch TV. However, watching TV was easily solved thanks to a MythTV script that can be easily integrated in XBMC, and thus used as a front-end for the MythTV back-end.

Once the software and hardware components at home were selected, the next step consisted on their integration to provide a functional system supporting interactivity with the final user. Interconnection of the HTPC with the display device, i.e., the TV set, was easily supported through high-definition multimedia interfaces (HDMI), already integrated in both devices. Then, we had to select and implement the services that will turn this platform into a socio-sanitary services platform. Before going further on this topic, it is important to remark some relevant aspects of the platform itself. As mentioned above, the TV set is used as the final presentation and interaction device. Thus, the platform is not a system itself, but a module of a larger distributed system extending the classical TV set with a portfolio of services. From the hardware point of view, the platform is a modular system extending a TV set with additional devices required by the services provided (e.g., web-cams, microphones, movement sensors, blood pressure monitors, etc.) using existing communication solutions like Bluetooth adapters, USB ports, or infrared sensors. This modular approach is a

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key feature of the system, and contributes to limit the final cost of the system, as the only peripherals needed will be off-the-shelf components in most cases. It also enables the possibility of adapting the final platform to any specific user's needs. This is a very important aspect taking into account the fact that potential users of the system range over a wide range of situations insofar dependence is concerned. Another key feature of the final system is its adaptation capabilities to the specific needs of potential users.

C. Network Structure

In order to support user interaction both with the services provided and the outside world, to collect and retrieve content, and to manage user data, a typical three-tier service architecture was implemented and deployed. Figure 1 above outlines the main components of this architecture, which are outlined below:

- **Business logic:** It is composed of a Login Server and an Extensible Messaging and Presence Protocol-compliant server (XMPP server) [8]. The Login Server provides user authentication and system adaptation. Users contact the Login Server to sign in the system. According to users' credentials and profile information, access is granted to the appropriate services while user interfaces are adapted to the specific needs of each user. Other actions supported by this server are new users' registration or service availability assessment. The XMPP server works as an adaptation layer to provide access to the actual user-oriented services available at the platform, both internal and external. The behavior of this element depends on the type of service accessed, as discussed in Section III below.
- **Client:** Users access the socio-sanitary services offered by the system using the hardware/software platform discussed above. Client equipment provides an adapted user interface that includes the required interaction devices according to each service and user profile (e.g., TV remotes, sensors, actuators, biomedical equipment, etc.). Note that the platform is designed for disabled or elder people that may present any kind of disability and typically spend a lot of time at home watching TV. Users may access any service provided to them according to their profile. The system also provides a Web management interface to administrators, that is, an interface enabling service and system managers to perform their tasks and to access to all the relevant information about the system.
- **Back-end:** This is an information server that manages data about users and service profiles. Relevant data may be distributed among several physical servers. For example, a central server linked to the login and XMPP servers may collect al relevant information needed by these servers, and additional servers may host the data needed by final services (e.g., content server in a streaming service, or communications management server in a videoconference service).

III. SERVICE PROVISION

Once the main structure of the system has been introduced, we will discuss along the next paragraphs how different users get access to the different services provided, and how they interact with each other. Different service provision schemes will require different communication methods. This is due to the fact that each service has an associated server, which may present specific characteristics that differ from the others. In order to facilitate to the reader the comprehension of all the communication procedures, the three basic service provision methods are illustrated below.

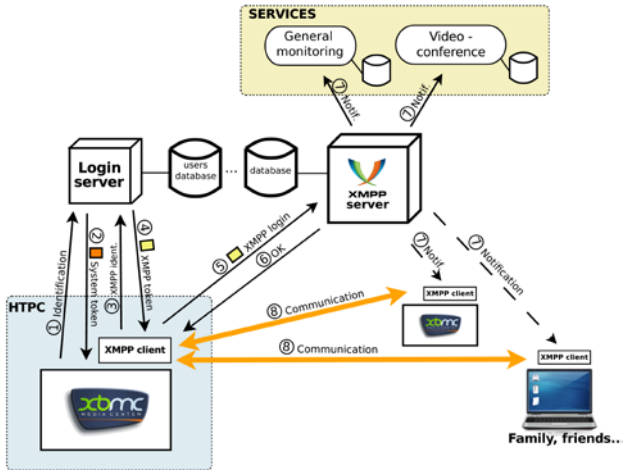

Figure 2. XMPP server communication

The platform was designed according to a quite simple but functional structure. On top of this structure all kind of services are inserted, including monitoring, communication, social integration, entertaining, rehabilitation, and educational services. After being developed, services may be added to the platform in a pretty simple way. The only requirements for service integration are that they have to be written in a Python language version supported by XBMC, and use libraries that are compatible with XBMC. These services may interact with a wide range of user devices, as long as they communicate through a standard protocol implemented in the PC platform (e.g., infrared, Bluetooth, USB, etc.).

Once the user has been signed in, an Extensible Messaging and Presence Protocol-compliant client (XMPP client) is automatically launched at the XMBC. The XMPP client requests an XMPP specific token from the login server, which contains the needed user information to login into the corresponding XMPP server.

The *User Session Management Service (USMS)* is a basic service that is included in every platform regardless of the actual user needs. This service handles authentication and personalization, that is, it has the responsibility of checking

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the user's identity as well as requesting the central server each user's initial configuration. This information is used, for example, to provide a personalized graphic user interface, or to identify specific interaction devices needed by specific users. Upon users' logout, USMS notifies every running service that the current user session has ended.

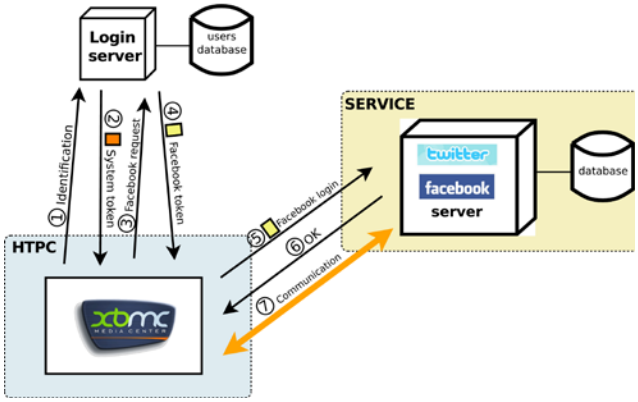

Figure 3. External server communication. Interactive services.

Once the user is logged into the XMPP server, service providers (e.g., videoconference server, medical monitoring equipment) and XMPP clients in other designated users' premises (e.g., friends, family members, caretakers) are notified. Other examples of services that require XMPP server notification reporting about the user's presence are presence control or every communication service that relies on the XMPP protocol to remotely communicate with other users. Figure 2 above outlines this scenario.

In case the user requires access to a third-party service provider (e.g., Facebook or Twitter), the system provides direct access to the corresponding external authentication facilities once initial sign-in has been completed as discussed above (c.f. Figure 3). Once the user has completed the access requirements of the external service, the corresponding access tokens are handled over to XBMC, and further communication takes place directly between XBMC and the external server, according to the provided Application Programmers' Interfaces (e.g., Facebook API).

In case the service accessed involves the provision of multimedia content (e.g., a broadcast or streaming service), the access tokens obtained after user authentication are handled over both to XBMC and to the multimedia content server (e.g., streaming server). Thus, when the user requests a multimedia content, XBMC will send the previously collected system token to the external server to authenticate itself and start the exchange of information. Then, the multimedia server will check the validity of the token and initiate multimedia content transfer. Figure 4 summarizes this process.

IV. INTERFACE DESIGN

Due to the profile of potential users, there were some relevant aspects related to interface design that were taken into account:

- People with visual deficiencies. Most elderly people have some kind of sight impairment. To overcome this situation, special care has been taken when designing the look and feel of the visual interface, and more specifically subtitles and other textual information [9]. Apart from that, eye-catching colors were used for active elements (e.g., clickable buttons) as well as easily identifiable images.
- People with lack of experience in the use of Information and Communication Technologies (ICT). Other common characteristic of the target population is that they are not accustomed to deal with new technologies. In most of the cases the use of this platform means their first contact with ICT. To address this issue, simple buttons rather than complex menus with many options have been used.
- People with cognitive difficulties. This platform is oriented to provide services both to elderly people and people with any kind of disability, including cognitive ones. Thus, it is possible that some users have difficulties to understand and reason about what is shown in the interface. Text content in interfaces has been carefully designed using simple straightforward expressions, avoiding for example complex or very long words.

The presently implemented interfaces are:

- A general common interface, where buttons are displayed following a 4x4 grid pattern, which are accessed using the four arrow keys of a standard TV remote. Apart from these four elements, OK/confirm and cancel/return buttons have also been included and mapped to the corresponding standard remote keys. In this interface, buttons are statically displayed and is the user the one that navigates using them.
- A scanning interface, which is specifically targeted to people with movement disabilities that make precise hand/arm movements difficult or impossible. In this case, every action and service can be accessed using a single button in the remote. This is achieved by moving buttons that rotate around the screen, being only one selected button at any time. The user waits for the button he or she wants to activate to have the focus. When this interface is operated through a movement-sensing device (e.g., Nintendo WiiMote), movements of the remote are mapped to instructions to move the focus of the active selection at the screen.
- Pointing interface: This interface is used in combination with the two interfaces discussed above, and is supported by the Nintendo WiiMote. It takes advantage of the pointer included in the WiiMote, which allows the selection of elements on the screen just by pointing at them.

Other options are scheduled to be implemented in the near future, as color-intuitive interfaces based on colored physical switches, eye tracking interfaces, or scanning-aided interfaces.

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V. DISCUSSION

Elder and disabled people's functional limitations often entail, among others, limited mobility, poverty, or inadequate medical treatment related to over- or under-subscription. The solution discussed above contributes to address this situation in a cost-effective way. First, it helps to overcome limited mobility by providing communication tools with both family and caretakers, and users' social environment. Besides, providing tools to supervise treatment or even to monitor users' health status facilitates the health control of this population sector. Note that the service architecture described above enables the integration of existing remote monitoring solutions or online services.

However, there are some challenges to overcome to guarantee the deployment of this solution. These challenges are technological, organizational and social. Connected products and services targeted to disabled or elder people proliferate but, apart from basic industry communication standards (e.g. Internet protocols, USB, Bluetooth, etc.), there are not standard interconnection higher-level procedures to enable the interaction among these systems and products. The system described above proposes a basic communication model based on application-layer standards, but the integration of specific services or product may require the development of the corresponding wrapper or adaptation layer.

On the other side, to guarantee service availability and a reasonable level of functional quality, supporting personnel with different profiles is needed. Part of the roles intended for system administrators or administrators of specific products and services may be provided by technical personnel in service providers or even the social environment of users, but in some cases specific personnel may be required (e.g. a health professional to monitor the intake of prescription medicines for users of a remote medication control system).

Finally, the introduction of these service platforms should not imply the further isolation at home or at nursing homes of users. These solutions may be seen as convenient technical approaches to replace the care of humans, but its ultimate function is to complement existing human-based care solutions by contributing to minimize the drawbacks of this kind of care (e.g. limited availability, human errors, fatigue, etc.)

VI. CONCLUSION

We have outlined the basic structure and organization of a socio-sanitary service platform that uses the TV set as the basic interaction element. We have introduced its architecture, and discussed its basic operation.

Tele-assistance is a very active market. In a scenario where new projects and products proliferate, the platform discussed in this paper presents relevant innovative features. First, it successfully integrates the traditional TV experience with interactive services and Internet. Besides, it is a product that can be classified as real low-cost requiring under 300 € investment per home. On the other hand, the platform has been designed to facilitate its market introduction, since the only requirements needed to operate at home are a standard TV set and an Internet connection. These aspects contribute to its acceptance by potential users. An original aspect that differences the developed system from other similar ones is its architecture. The hardware configuration has a clear modular structure, which favors its simple extension using a broad range of external devices. This structure also enables the system to be completely customizable and re-usable. Indeed, both services and interfaces are automatically configured according to the profile of the user accessing the platform. Another relevant characteristic of this platform is its original approach to service provision, as the solution has been conceived as a base system on top of which diverse types of services can be easily deployed. The base system may be extended with new services and new interfaces specifically designed to fulfill specific user needs.

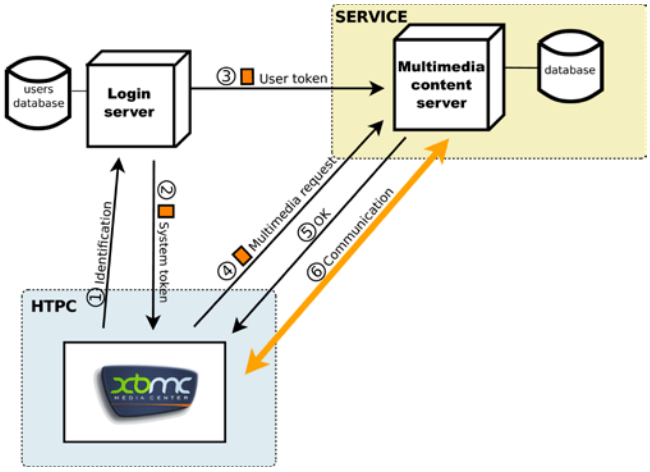

Figure 4. External server communication. Multimedia.

Apart from this, the developed platform uses open standards and widely available devices and software components. To sum up, with this system we show that it is possible to bring new technologies closer to people that are not used to them, and also to utilize new technologies to improve the quality of life of people that is usually disconnected from the rest of the society.

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