31st Annual International Conference of the IEEE EMBS
Minneapolis, Minnesota, USA, September 2-6, 2009

Home e-health system integration in the Smart Home through a common media server

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Abstract— **Home e-health systems and services are revealed as one of the most important challenges to promote Quality of Life related to Health in the Information Society. Leading companies have worked on e-health systems although the majority of them are addressed to hospital or primary care settings. The solution detailed in this paper offers a personal health system to be integrated with Smart Home services platform to support home based e-care. Thus, the home e-health system and architecture detailed in this research work is ready to supply a seamless personal care solution both from the biomedical data analysis, service provision, security guarantee and information management´s point of view. The solution is ready to be integrated within the Accessible Digital Home, a living lab managed by Universidad Politécnica de Madrid for R&D activities.**

I. Introduction

The health care cost is of increasing concern for almost any government. E-health develops health care in a more effective way optimizing the existing resources in order to improve the user experience [1]. This is a well-known fact for governments and companies that are trying to develop feasible business models and useful e-health tools for dealing with limited resources for health care [2].

The Smart Home Concept has been developed to a very large extend in the last years. Nowadays, a large number of research projects are carried out in Europe with the Smart Home as the main scenario or even the main goal of the project [3].

A Smart Home contains all the necessary elements to be an optimal platform to deploy e-health applications. There are many research works about the development of telecare services in smart homes that reveal this environment as a suitable scenario for home care services [4].

Operational requirements in a Smart Home are selected to optimize user experience in terms usability, security, and comfort, using domestic appliances like TV, computer, phone etc.

The interaction between people and technology is of specific importance in home e-health applications since people may not have enough knowledge about technology and they forced into the double role of patient and user. Design-for-all principles must guide the solutions developed in order to get the acceptance of all users, even the ones with special needs and those with zero-knowledge.

Addressing this issue, guidelines for human factor in telecare systems are being drafted by ETSI [5]. Although telecare is only a subset of e-health, it covers the weakest side of the whole system: the user side. This work assumes these guidelines as a requirement document in the analysis stage.

In this paper the development of suitable home integrated e-health services compliant with human factor guidelines are presented using a common media server as core of the home-health monitoring service. Only the home side of the system will be covered since is the only side that can benefit from Smart Home. The server side is out of the scope of this paper because it depends on the infrastructure and operations of each health center.

II. Background

A. Smart Home

A Smart Home is considered as an open user-oriented service platform using domestic resources. Currently, the most common Smart Home scenario has a broadband Internet connection, Windows or Linux-based Media Center, home computer network and TV as well as other appliances like computers interconnected to the media center.

Smart home environment requires standards in order to allow the integration of new devices, services and applications. Digital Living Network Alliance (DLNA) standards for the interconnection of multimedia and entertainment devices or OSGi platform standards for the deployment and management of services are some examples of the current Smart Home standards. However, these standards do not habilitate health care services integration, since they have not been developed with such purpose.

Manuscript received April 23, 2009.

This work was supported in part by the Social Council of the Universidad Politécnica de Madrid under the Doctoral Education Grants Program and by the Ministry of Education under the Research, Development and Innovation National Program, SEMPER project.

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B. Human Factors

The so-called human factor guidelines for telecare services [3] covers three main areas: Users' trust, users' interaction and service and organization aspects. Each of these areas must be dealt with in the proposed system.

C. E-health systems

Several companies (from different areas: ICT, telecare…) have developed its own home e-health solution to be used at home by unskilled users.

For instance Microsoft and Google have developed Personal Health Record (PHR) databases, distributed databases that allow the communication between users and health staff through third party software. Intel or Tunstall have developed complete tele-health solutions that allow telemonitoring through specific hardware (Intel Health Guide PHS6000 and Tunstall RTX337X). These solutions have a server side to be used by medical staff and client side designed to facilitate the home-users interaction.

III. Home e-health System Design

A. Requirements

The proposed system is a complete home e-health solution that enables home-healthcare monitoring by establishing a communication link between the patient at home and the caring staff of the health center. The system gathers data from the monitoring devices and transmits them to the health center. Patient data will be received and managed at the health center enabling patient monitoring and telecare.

To ensure an open and adequate management of the patient information the information collected in the e-health system detailed in this paper follows the Health Level 7 Clinical Document Architecture (HL7 CDA) [6] to manage the Electronic Patient Record (EPR). Each health center has different operation process and working routines, therefore the system must be able to adapt to those specific settings.

In addition as previously mentioned, the system must comply with the human factor guideline from ETSI [5].

Since the core of home e-health system is the functional core of a Smart Home, the system must be able to be deployed on the most common Smart Home platforms without changes in its functionality.

B. System Architecture

As shown in Fig. 1, the client side of the system is subdivided in subsystems:

--E-health core: It is the first component to be launched and it is the coordinator of the rest of subsystems. It configures and distributes the working instructions to all the subsystems, saves a local copy of the measurements and through the setup manager records all the available resources in the Smart Home.

--User interface manager: This subsystem handles several different user interfaces in order to offer the most suitable one to meet the specific user's needs. It can take the control of the available smart house interface resources included in the e-health core database.

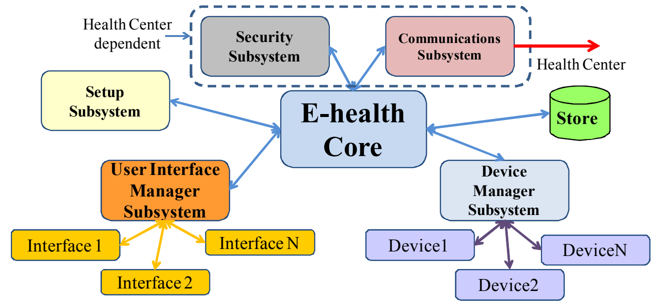

Fig. 1. General system architecture showing with the subsystems components and the coordination of the e-health core.

--Device manager: It gathers the information from the monitoring devices and allows the addition of new devices. A device driver subsystem is incorporated in order to add devices with different protocols. It has been designed in a flexible way in order to allow the inclusion of several devices compliant with industry standards as well as prototype devices for research activities.

--Setup manager: It guides the patients in the setup of the e-health system. Checks the user needs in the first deployment or when a new e-health session is initiated. Moreover it finds the available resources at the Smart Home and includes them in the e-health core database.

--Security: The security subsystem handles all security issues of the application. Inside the home it applies security mechanisms to the information stored by the home system. Outside the home, it ensures that the information is transmitted in a secure manner. The security setting of the communication is adjustable to the needs and protocols of each health center.

--Communications: This subsystem handles the communication with the health center. Together with the user interface manager and the security manager, it can take the control of available Smart Home resources included in the e-health core. Note that protocol used to transmit the patient data is set by the health center.

Some of the subsystems must be developed from scratch and others can use the available Smart Home resources.

IV. Implementation Results.

A. Scenario

The system has been deployed in the Accessible Digital Home (ADH), a 90 m2 living lab sited at the EUIT Telecomunicación, Universidad Politécnica de Madrid. This smart house is a lab that is used both as a test scenario with final users and as a research facility. This environment imposes the next additional requirements to the system:

--Hardware appliance and communications: the ADH provides wideband ADSL communication, a Windows Media Center device placed in the living room with Bluetooth support, connected to the TV and the home network.

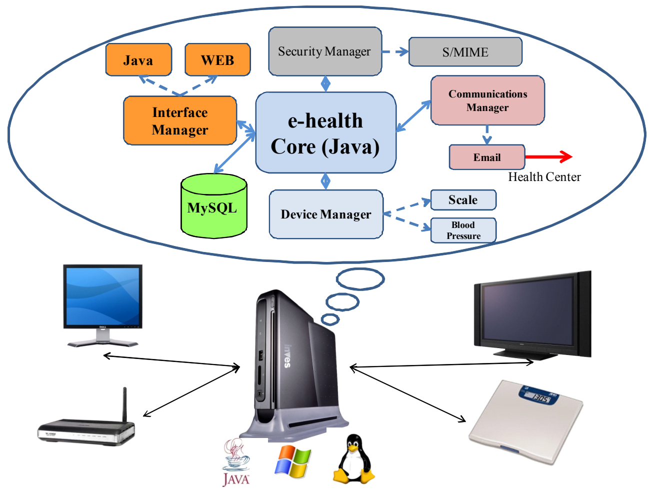

Fig. 2. Scenario architecture adapted the Smart Home constraints.

--Health center: The main requirement is that only email communication is allowed. The system must send the information to a previously configured email inbox.

--Monitor devices: Two commercially available monitoring devices by A&D Medical have been tested for clinical use: Blood Pressure Monitor (UA-767 Series) and Weight Scale monitor (UA-321 series) [7]. Both with Bluetooth interface.

As previously commented, a Smart Home often provides its own interfaces that have been implemented to interact in the most suitable way with the user. The setup manager handles this process discovering and setting the different home interfaces and making them available to the applications. However, in the proposed scenario, there is not previous home interface installed, therefore the setup manager is not needed and the interface manager has its own application interfaces i.e. the residential devices e.g. TV.

With these requirements, the detailed design of the final system becomes as showed in Fig. 2.

B. Implementation and deployment

Java language has been used to implement all the system. This language provides a robust programming paradigm and provides a lot of interesting features that ease the implementation of the system proposed.

The cryptography and S/MIME protocol support is provided by Bouncy Castle libraries. The Bluetooth support, JSR-82 compliant, is provided by Bluecove library.

The system has been checked on different Microsoft Windows platforms (Windows XP SP2 and Windows Media Center) and Linux (Ubuntu 8.10 and Debian 5.0). Currently is installed and running in Windows Media Center according to the scenario proposed.

Currently the first phase of the implementation is finished. Several functionalities, such as setup manager, have not been implemented yet.

C. Operations

An operational chart containing both the external and internal operations of the system is shown in Fig.3. The following explanation illustrates, from a user and a system architecture point of view, the typical scenario where the weight of the user is measured using a Bluetooth-enabled weight scale.

1) Once the user uses the monitoring device, in this case a scale, the weight is measured and the scale stores the measurement. The scale then searches for the media center device, which it is able to receive the patient data through a Bluetooth serial port connection. From the architecture point of view the e-health core request to the device manager to

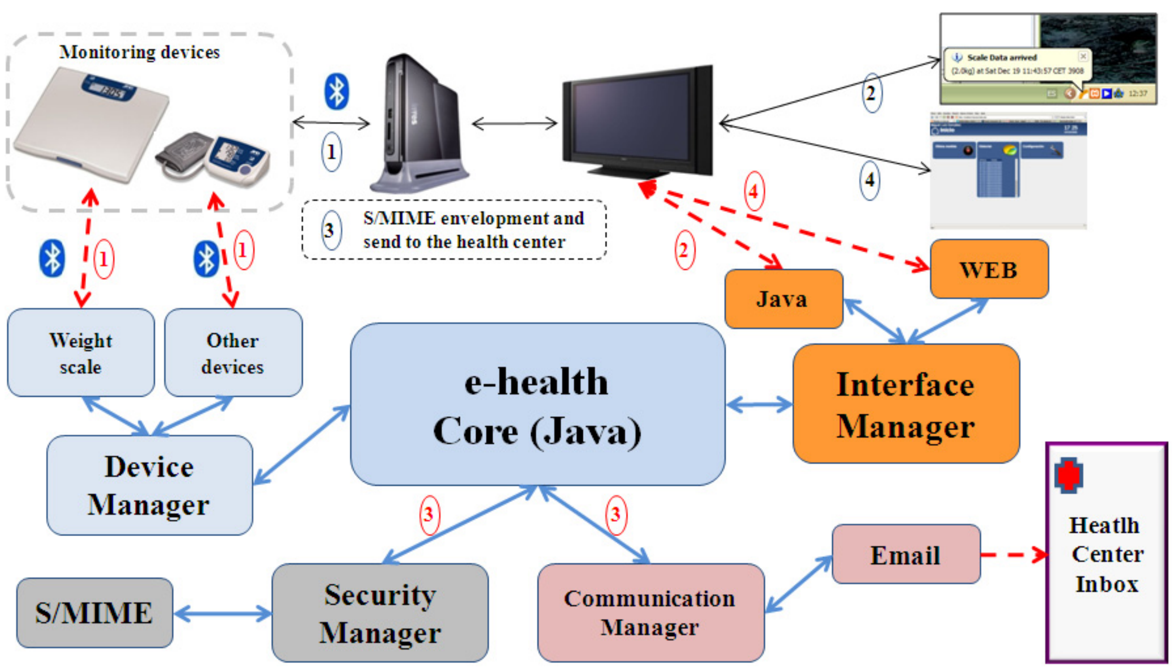

Fig. 3. Operation Chart indicating the operational dependencies from the user and the architecture point of view.

listen for all available devices. The Device Manager loads all the specific-device modules. The scale module detects the scale request and starts the connection phase. When the serial port connection is established, the scale module transmits the measured data to the e-health core through the device manager.

2) The media center notifies upon measurement reception through the TV to the user but he is not required to participate in the confirmation of the measurement reception. This notification is indicated by the interface manager and a java GUI application.

3) The next step is to securely protect the patient monitoring data and transmit it to the health center. The e-health core requests to the security manager to envelop the measurement with S/MIME protocol. Once the envelopment is done, the communication manager receives the request for transmission of the encrypted message with the measurement to the health center from the e-health core and the data is transmitted by email to the inbox of the Health care center.

4) The user has access to his/her own measurements using the media center web application. This way the measurements will be shown through the TV in tables and trend charts.

V. VALIDATION

The validation is currently an ongoing work being done at ADH. At first, a group of technical staff are obtaining daily measurements with the aim to test the stability and fidelity of the system. Since measurements stored and sent continuously an intensive security analysis is also being done. The next steps are two independent tests where the user interaction with real patients will be checked at home and the access to the data information received through email protocol at the health center will be checked.

VI. DISCUSSION

A useful and effective home e-health service should use the available resources of the Smart Home. Most probably, these resources have been chosen according to the user needs and they are very well adapted, customized and personalized. Thus allowing the e-health solution to deal with health matters and avoid very complex issues like usability or accessibility. New services do not require to be provided with new interfaces because the Smart Home provides with already user tailored interfaces.

The services and restrictions of a Smart Home must be considered in the analysis and the design stage of any product integrated in this environment. In order to get the best of this environment, the products must use the interface, communications, and security features of the Smart Home.

The proposed design centered on the media server is versatile enough to cover many different scenarios with smart homes and e-health centers. If the user changes residence to another Smart Home or health care service provider, the subsystems can be reconfigured in order to support the new scenario.

The solutions from Google and Microsoft cannot be considered complete e-health solutions since e-health solutions have to allow the establishment of health sessions between patients-at-home and the health center staff. Solutions from Tunstall and Intel are complete e-health solutions in this sense but they do not take advantage of the huge potential that a Smart home provides, especially in usability terms.

However, smart homes are not still widely deployed and the main advantages of this platform are not within reach of many users. A massive adoption of Smart Home practices like an open service platform is needed in order to take advantage of these solutions. The home e-health systems together with the multimedia systems are called to be the killer applications of the Smart Home.

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