

An Intelligent Interactive Healthcare Services Environment for Assisted Living at Home

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Abstract — Since the population of elderly people grows absolutely and in relation to the overall population in the world, the improvement of the quality of life of elderly people at home is of a great importance. This can be achieved through the development of generic technologies for managing their domestic ambient environment consisting of white goods, entertainment equipment and home automation systems in order to increase their autonomy and safety. In this context, the provision intelligent interactive healthcare services will improve their daily life and allowing at the same time the continuous monitoring of their health and their effective treatment.

Keywords - Healthcare Services, Patient Monitoring, Assisted Living at Home

I. INTRODUCTION

Worldwide, the population of elderly people grows absolutely and in relation to the overall population. This means that more and more consumers will be over 60 years of age in the near future. Several studies and surveys identified a lack of products and services designed for the special needs of elderly people. Mostly, new products have been developed with high sophisticated and innovative features. However, the usual behavior of a huge number of these devices is too complex. It is quite normal that the health condition of each human being is getting worse with the increasing of age. Depending on personal limitations, it becomes more and more difficult for elderly people to carry out all the daily tasks. Even simple services, supporting the daily life and giving back a little autonomy, are missing. It is a challenging issue for someone to deal with these special needs of elderly people especially in the healthcare monitoring and treatment. The goal of the INHOME project is to provide the means for improving the quality of life of elderly people at home by developing generic technologies for managing their domestic ambient environment, consisted of white goods, entertainment equipment and home automation systems with the aim to increase their autonomy and safety [1],

[2]. Monitoring of different types of chronic diseases of elderly people in an in-home environment relies heavily on patients' self-monitoring of their disease conditions [3]. In recent years, telemonitoring systems, which allow the transmission of patient's data to a hospital's central database and offer immediate access to the data by the care providers, is of a great importance [4], [5]. From the healthcare delivery system point of view, the data delivery will produce an evolving picture of a patient at any given time, taking into account diagnoses and treatments, successes and setbacks [6]. The system would assess the current level of functionality and interactively coach the patient to higher levels of functionality. The consistency of continuous monitoring would eliminate much of the inaccuracy from the current random interactions between patients and physicians [7], [8]. Periodically, this data would be reviewed (determined by medical parameters and health plan factors) by professionals trained at such data evaluation. The medical devices used are described and the types of diseases which are monitored are summarized in the following sections. The User Group is provided by the Health Centre of Vyronea (HCV), which is specialised in the provision of medical services to elderly people at home. The medical personnel are also involved in the requirements specification for aged people. The institute offers some of the houses under surveillance to be used as application testbeds and assist in the evaluation phase of the INHOME technology. Thus, this paper is organized as follows: Section 2 presents the overall network architecture, section 3 discusses the health and activity monitoring framework. Section 4 presents the A/V streaming and personal data acquisition by medical devices within the home environment, and finally, section 4 concludes the paper.

II. THE OVERALL NETWORK ARCHITECTURE

The requirements specification and the showcase descriptions identified the need for several devices, sensors and

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terminals to enable the different kinds of services for elderly people. To allow communication between different devices, a network architecture is needed to connect them. The overall network architecture with all involved device categories and intermediate network entities is shown in Figure 1. The concept of a centralized gateway as communication and interworking entity is utilized. In this scenario, the gateway is the only device directly connected to the Internet and external service providers. All other home devices are connected to the gateway. With only one exception; there is no direct communication flow between the devices. All messages issued by the devices are routed through the gateway. Afterwards, the gateway processes and forwards the information either to WAN or to LAN entities [9]. Ethernet is used as a basic transmission technology. Since most devices are equipped with Ethernet sockets and pre-configured cabling is available, the installation procedure becomes rather easy. Also, nearly all the gateways available on the market are equipped with a build-in wireless network interface. The dominating technology for Wireless LAN (WLAN) communication follows the IEEE standards 802.11 a, b, g or n.

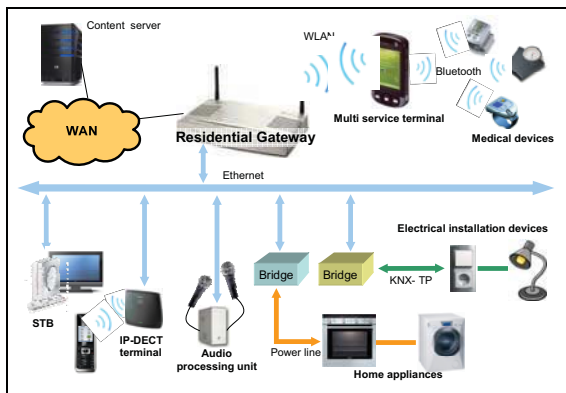


Figure 1. The INHOME overall network architecture and devices

Some areas of the in-home data communication have special demands. Thus, many vendors of white goods use Powerline technology for data communication. Similarly, requirements exist for cordless voice communication products and electrical installation devices. Due to cost issues, gateway manufacturers do not build-in second row technologies like DECT, Powerline or Konnex. The use of bridges is the most common solution to connect devices, based on these technologies, to the home network. Normally, such an intermediate network entity is equipped with two different physical interfaces. In our case, bridges are used for Konnex Twisted Pair and for Powerline. The residential gateway plays the role of the coordinating information requests. It establishes the connection to appropriate content servers and forwards the requests of the service applications. Therefore, the architecture is enhanced by a Multi Service Terminal which may act as a repeater increasing the limited coverage of the Bluetooth devices.

III. HEALTH AND ACTIVITY MONITORING FRAMEWORK

The health care services INHOME wants to develop are using various medical devices. For measuring blood pressure, body weight and electric cardiac values special types of devices

are needed with a build-in data transmission interface. An example of a monitoring framework is shown in Figure 2. The video sub-system typically consists of an IP-capable camera that can be controlled from the Health Centre. The Bio-sensor can provide various measures like heart beat, blood pressure or glucose ratio measures depending on what is the most relevant for the monitored user.

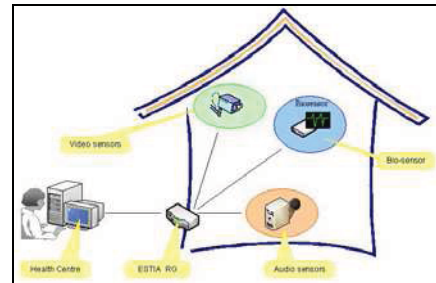


Figure 2. An example of monitoring framework

To achieve this, several sub-systems are involved, each of them having a precise role and presenting specific requirements. The medical devices must be available to communicate with the platform mainly using a wireless channel. Bluetooth Technology covers most of the requirements for wireless connectivity, power consumption, and moreover it allows easy setup of a wireless sensor network, offering efficient device and service discovery mechanisms [10]. For this reason, most of the wireless communication related to the acquisition of data from medical devices will be covered via the use of the Bluetooth Technology. The medical devices that are used do not support self-configuration functionality [11]. The only configuration allowed in most of the cases takes place via the transmission of specific commands (streams of bytes) to the device using the wireless channel, according to the communication protocol supported by the device. In some devices, only the setup of basic parameters (e.g. internal clock) is allowed, while in others, several modes can be defined, according to which the device transmits data in various manners (e.g. continuously every X seconds etc.). The Bluetooth communication logic will be executed at INHOME terminal, which acts as a mediator between the medical devices and the INHOME residential gateway, where the relative services will be built on. The reason for this, is that in order to achieve successful data transmission from the devices to the gateway (in case that a direct Bluetooth connection was chosen), each device has to be in proximity with the gateway. Since this cannot be ensured, especially in a home environment where the user may move around rooms, the most reasonable solution is to achieve a Bluetooth connection with the INHOME terminal (which will be carried by the user during the measurement). The terminal will then wirelessly (e.g. over WLAN) send the data over a connection (e.g. a socket connection) to the residential gateway and the various services on the gateway will act on these data (e.g. will send them to the appropriate doctor etc).

IV. A/V STREAMING AND PERSONAL DATA ACQUISITION BY MEDICAL DEVICES WITHIN THE HOME ENVIRONMENT

This section discusses the architectural needs of the mechanisms that allow a flexible and easy-to-use A/V

communication of the user with a person of his choice whereby the most important consist of the medical center or another person that the user would like to communicate with, like a relative or a neighbor.

A. Flexible AV stream handling (AV communication with the medical center)

The user, through the INHOME mobile terminal, selects, through a very simple UI, the person he wants to have a video call with and optionally the terminal on which the video telephony stream should be displayed and the video call is then established automatically. A user will be able to perform an A/V session either via a TV set or the INHOME mobile terminal. Additionally, a user will have the capability to transfer A/V streams between TV set and INHOME terminal and continue with the same A/V session (Figure 3). The user will be able to activate a session handover of the AV content, for example when moving from the garden (mobile terminal) to the living room (TV set) and vice versa [1]. This allows media streams to follow the user to different terminals/places within the home environment.

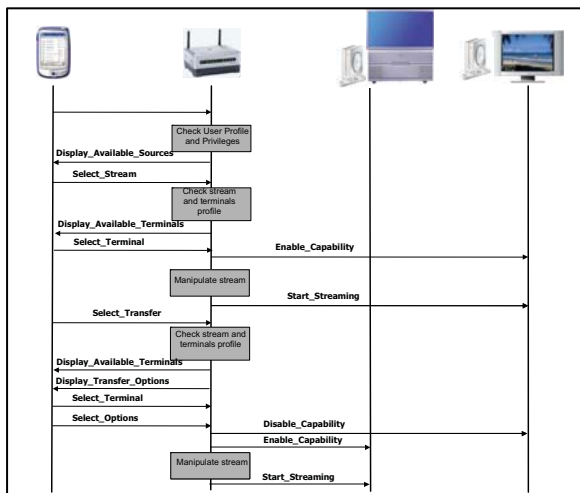


Figure 3. A/V Session initiation and handover

From a technological point of view the A/V stream could be delivered to any capable device within the household but the focus will be put on the most relevant devices for the target user group consisting of the TV set attached to an appropriate set-top-box (STB) and the INHOME mobile terminal. Every user within the home environment will have a personal ID stored in his profile on the residential gateway. The gateway shall incorporate the necessary mechanisms to support a simple-to-use user identification, and implement the automatic configuration of the associated system components, based on the specific user profile. The presentation of the available AV sources and visualization terminals constitutes part of the functionality that is based on the aforementioned profile.

A streaming server application, running on the A/V server, shall be responsible for the consolidation and controlled distribution of the content. The server, based on the characteristics of the selected terminal, appropriately formulates the content, to make optimal utilization of resources, while achieving the best possible user experience.

The discussed scenario involves the bidirectional handling of video streams. More specifically, the stream coming from the medical centre is handled like any other entertainment-related AV stream. However, the stream that goes from the house to the medical centre may also be in need of handling by the system [2]. From this point of view, the stream is not handed over from one terminal to another, but instead, the source may be changed from the integrated camera on the mobile terminal, to a fixed, higher quality camera inside the house. In addition, when medical equipment provides interfaces to expose its measurement results, this information will also be transferred to the medical centre either synchronous or asynchronous to the video stream. This will most probably not be superimposed, but provided in a separate “window” resulting in the display of mixed AV and text information coming from medical devices on the physician’s terminal. During each step of the handover, the user is presented with the available choices only (e.g. temporary handover, end temporary handover, pause, etc.) thus avoiding to clutter the limited screen area of the INHOME terminal with the entire options set offered by the A/V environment. In the “standard” case, the user selects A/V session and the source (person, Video, etc.) and, based on the profile of the user, the session starts on the default terminal with the default options.

1. The user selects the audio/video telephony function on the INHOME terminal. A message is sent to the gateway containing user information
2. The gateway checks which media sources are available for this user and sends back a list of sources (e.g. medical center, pharmacy, relatives).
3. The list is displayed on the screen and the user selects his preferred stream. This information is send to the gateway.
4. After verifying stream requirements and terminal capabilities, the gateway sends back a list of terminals which fit to be used.
5. The user selects the terminal which is the most convenient for him and the gateway enables the capabilities of this device.
6. In case that the selected stream does not fit to the capabilities of the device, the gateway will manipulate (transcode, transrate) the media stream and will start the streaming.
7. If the user has to move to another room, he will be able to carry the running A/V stream with him by selecting “Transfer” on his INHOME terminal that sends this request to the gateway.
8. The gateway itself verifies again which terminals could be used and sends back a list to the user’s INHOME terminal. Additionally, transferee options like “transfer in pause mode” will be reported to the user.
9. The user selects the new terminal and his preferred option by sending back an appropriate message to the gateway.
10. The gateway disables the old terminal and enables the newly selected.
11. Depending on the capabilities of the new terminal the stream has to be manipulated in another way by the gateway. Following, this gateway starts the A/V stream.

B. Personal Data Acquisition by Medical Devices Within The Home Environment

A service based on the acquisition of some data from medical devices operating in the user's environment is considered. The INHOME architecture is responsible initially to acquire the data from the devices. Afterwards, a check for possible alarm conditions, related to the values of the measurements, takes place. In case that some alarms exist, some automatic actions take place in order to enable the person to contact the physician in an easy way. The elements participating in this showcase are the following:

- The medical devices, which are used in order to perform some measurements (e.g. Blood Pressure, Cardiac Pulse, Body Weight etc).
- The INHOME terminal, which is responsible to communicate with the devices in order to acquire those measurements.
- The residential gateway, which is responsible to run some services based on the data produced by the medical device.
- The TV device, which is responsible to display the measurements in a user friendly manner.
- The DECT phone, which enables the user to contact his/her physician.

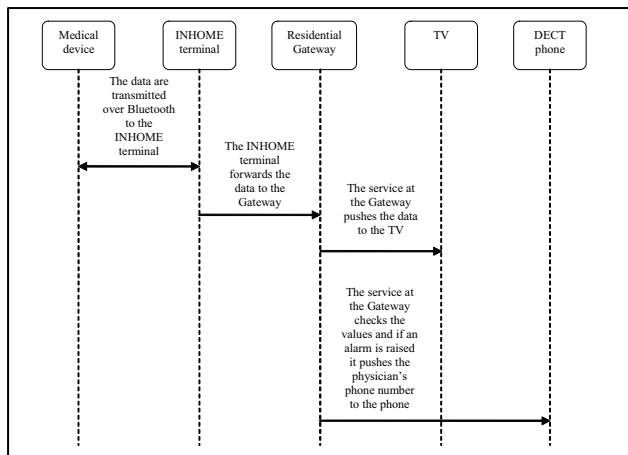


Figure 4. MSC for personal data acquisition showcase

The information flow, related to personal data acquisition by medical devices within the home environment, is depicted in figure 4. When the user performs a measurement, using one of these devices, the device communicates with the INHOME terminal in order to upload this measurement. This procedure requires the implementation of the (most of the times proprietary) device communication protocol at the side of the terminal. In the case of Bluetooth communication, the INHOME terminal was selected as an intermediate collection point due to the fact that it is carried by the user, so it can always be in the proximity of the medical devices, considering people moving around the house. In the case where a direct Bluetooth communication with the gateway was to be established, the Bluetooth connectivity would not be always guaranteed, since the medical device could be out of the Bluetooth coverage of the gateway. After having acquired the data from the medical devices, the terminal sends this data

through a WLAN (wider coverage) to the residential gateway, which in turn processes this data. Some key processing is related with the identification of alarm values based on the normal range for each type of measurement. The service execution in the gateway is also responsible to send the data to the TV in order to enable the user to view the values (and thus assisting elderly people with vision problems). Upon the detection of an alarm condition, the service in the gateway is also responsible to discover the phone number of the physician, which can be stored locally or at a remote location and send the phone number to the DECT phone in order to allow the user to avoid the manual dialing of the number.

V. CONCLUSIONS

An intelligent healthcare service environment will produce an evolving picture of a patient at any given time, taking into account diagnoses and treatments, successes and setbacks. Collecting continual interaction with detailed patient status would allow the immediate, simultaneous and more effective treatment of the patient. In this paper, an intelligent interactive healthcare services environment for Assisted Living at Home is presented. This research work has been developed under the INHOME project, the goal of which is to provide solutions for improving the quality of life of elderly people at home by developing generic technologies for managing their domestic ambient environment, comprised of white goods, entertainment equipment and home automation systems with the aim to increase their autonomy and safety and for providing at the same time appropriate medical assistance, when needed.

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