Ambient Assisted Living in Rural Areas: Vision and Pilot Application

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Abstract. Rural areas cover 90% of the EU's territory and half of the Europeans live in these areas. It is of high priority to ensure the full participation right of these people in the information society, which means considering them during the newest developments (such as AAL) as well. In this paper, we envision a PDA-centered medical sensor system setup that is suitable for the AAL homecare scenario and identify a problem that can easily arise in rural areas. Additionally, we intruduce a pilot application that can act as the seed of the envisioned system and gives an answer to the identified problems.

1 Introduction

Rural areas cover 90% of the (enlarged) EU's territory and approximately half of the Europeans live in these rural and remote areas. It is of high priority to ensure the full participation right of these people in the information society, which means considering them during the newest developments (such as AAL) as well. However, rural and remote areas can impose additional problems to those experienced in urban environments.

First, let us consider the general problems of AAL. We can say that ambient assisted living and ambient assisted home care is at our doorstep. Several mobile medical sensors are already available: mobile ECG devices, pulse oxymeters, blood pressure monitors, glucometers, etc. are produced by various vendors. Still, these sensors cannot reach the aims of AAL alone. To be able to *intelligently assist* our lives, these devices should overcome some of their major deficiencies: first, these devices are usually short of *resources* (memory and computational power), and secondly, the vital data gathered by the sensors are not processed in an *integrated* manner, i.e., the devices work without knowing the data sensed by each other. However, the seemingly trivial solution, i.e., to extend the sensors with more resources may not be a viable one because of several constraints on usability such as size, weight or energy consumption.

We propose a construction which offers a solution for the above mentioned problems but does not hinder usability and uses already available devices thus making AAL able to cross the doorstep. In our vision, the centre of ambient assisted living is a personal digital assistant – quite simmilarly as PDAs or smartphones start to play a central role in our normal lives. PDAs are small, mobile and they are equipped with sufficient resources to process and integrate data coming from several sources. And last but not least, they are able to connect (wirelessly) to sensors.

And what about the problems of the rural and remote areas? In this paper we focus on one: providing cost effective internet coverage for scarcely inhabited areas is not an easy task. Wired internet connections, GPRS-based mobile connections, or full WiFi coverage provided by hotspots might all turn out to be too expensive in such scenarios. Thus, we propose to use the PDAs as active members of an ad-hoc wireless mesh network where the internet connectivity is provided by a gateway and the ad-hoc network together, without the need of additional fixed components.

In this paper, we intruduce a pilot application that can act as the seed of the envisioned system. We connected a mobile ECG device to the Nokia N800 Internet Tablet using Bluetooth technology and extended the capabilities of the sensor by exploiting the resources of the PDA. As the N800 runs on an open source platform, the extension of the current system with additional sensors becomes easy. Additionally, we adapted a network layer application for the N800 which makes it able to act as an active device of an ad-hoc network.

The rest of the paper is organized as follows: Section 2 describes the hardware components of our pilot application in detail, Section 3 gives the details of the AAL functionality implemented in the application, and in Section 4 we give some information on the network layer designed for rural areas. Finally, in Section 6 we conclude our work and give directions for future work.

2 System Components

In our pilot project, codenamed SmartECG [1], we used the CardioBlue mobile ECG event recorder manufactured by Meditech Ltd., which is a typical representative of the currently available mobile (medical) sensors. The device is able to record 1-5 ECG channels, either automatically in regular intervals or at the patients request, but it can store only 60 minutes of recorded data in its internal memory. Moreover, while its 16-bits core running at 8MHz consumes extremely low power, it is not suitable for complex signal processing purposes. Fortunately, CardioBlue is equipped with a Bluetooth interface which both allows the configuration of the device and grants access to the sensed ECG data, even in real time. This feauture opens the possibility to extend the functionality of this highly resource-constrained device.

It turned out that the Nokia N800 Internet Tablet (and its predecessor, the Nokia 770) is an ideal tool for this extension. It has an easy to use user interface (large and high-resolution touch screen display), sufficient computational power and data storage for performing complex tasks (32-bits ARM core clocked at 320MHz, 128MB RAM, and 256MB flash memory), standard wireless interfaces that allow connectivity to other devices (Bluetooth and WiFi), and an easily extensible software environment (Linux operating system and Maemo desktop

Fig. 1. The system setup: A Nokia Internet Tablet, a CardioBlue mobile ECG device, and an "artificial patient".

environment both being open source). And besides (or against) its strengths, the Tablet remains a leightweight and portable device.

Thus, with these two devices (see Fig. 1) we can demonstrate that AAL is not the future, but it can already be made a part of our lives today with the help of the available tools.

3 The SmartECG Application

When designing the functionality extension of CardioBlue, we had two application areas in mind: the PDA can be useful in the clinical domain and, naturally, in the homecare scenario. Thus, the SmartECG application that runs on the N800 has two operation modes: the "doctor" and the "patient" modes.

3.1 Doctor Mode

The doctor mode offers full access to the CardioBlue device. In this mode, the PDA can be used to configure the ECG device to periodically make records, it can download the data that is stored in the memory of the device, and it is able to display the downloaded (multichannel) ECG graphs (see Fig. 2).

What is more important and useful in a clinical scenario however, in doctor mode, the SmartECG application is capable of maintaining a live connection with the CardioBlue device and accessing the ECG data in real time. Moreover, we implemented the feature of transferring the ECG data to a remote computer through the internet (using the PDA's WiFi interface), and developed a multiplatform client application (running on both Windows and Linux), which is capable of receiving and displaying the real-time ECG data. This feature, when used together with a VoIP application (a GoogleTalk-compatible client comes preinstalled with N800) makes the consultation between remote-located members of a medical group (nurses, doctors, and/or experts) possible.

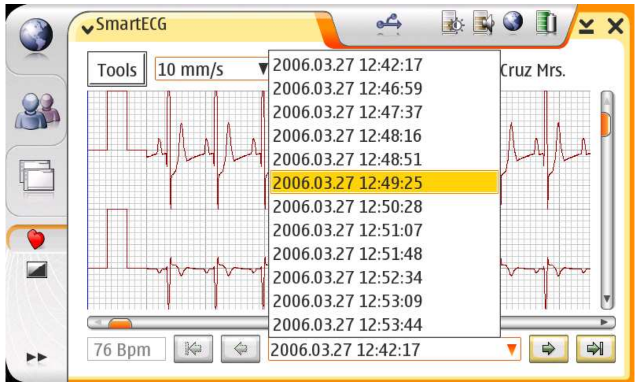

Fig. 2. Browsing through downloaded ECG data in doctor mode.

3.2 Patient Mode

The patient mode is specifically designed for a homecare scenario. In this mode, the user interface is intentionally very simple, consisting of only three large buttons that fill the whole screen (see Fig. 3a). This allows even elderly people with sight deterioration to activate the required functionality.

These functionalities are the following: the ECG data stored in the built-in memory of the CardioBlue can be downloaded to the Internet Tablet thus freeing up valuable space in the ECG device. Additionally, when connected to the internet, the already downloaded ECG records can be sent to the doctor via e-mail. And finally, if the patient has to remove the electrodes at home and then wants to place them back (e.g., because of bathing), then SmartECG can provide help by displaying the correct placement of electrodes (see Fig. 3b).

Besides pressing one of the three buttons and thus activating the above described functionalities the patient has nothing to fiddle with the application. All the operational parameters, even the e-mail address where the ECG records are sent, are preconfigured by the doctor, which makes the use of the application simple enough to be useful in a homecare situation.

4 Network Layer

The prototype application that was described in the previous section can work in two different wireless network environments. Naturally, it can connect to traditional WiFi hotspots, thus making use of the coverage that is becoming more widely used in urban areas, even in private homes. More and more medical institutes and hospitals deploy internal wireless networks, which offers new opportunities for the clinical application of the system.

For those who live in rural, remote and scarcely inhabited areas, the application offers an alternative solution [2]. The Internet Tablet can be equipped with

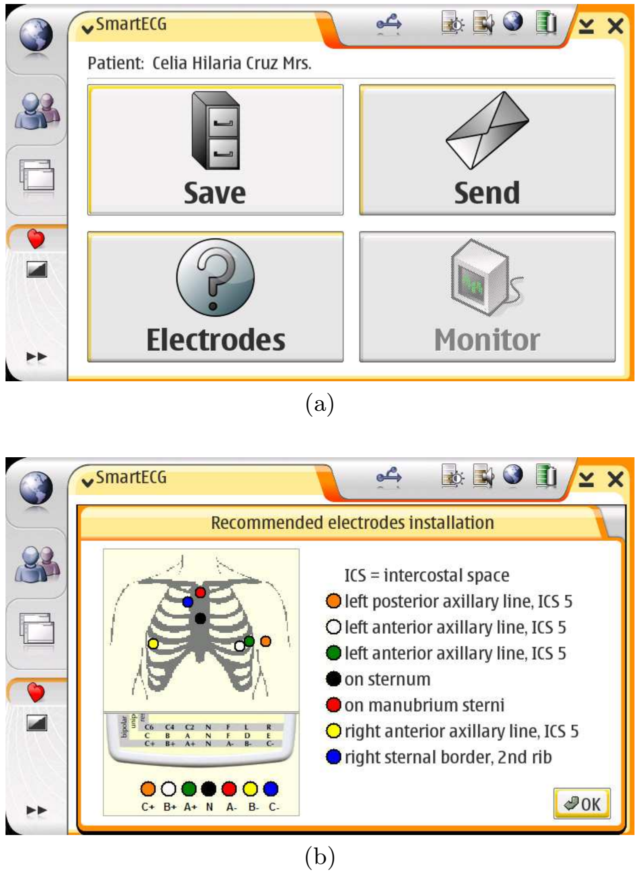

Fig. 3. Patient mode: (a) the functionality accessible to patients, (b) help to replace the electrodes in a correct way.

an ad-hoc wireless mesh network layer, which makes the PDA capable of being an active device in the wireless network and transferring data (ECG records, among others) over it. This eliminates the need for statically deployed wireless devices (except for one gateway node, which connects the ad-hoc network to the rest of the internet) and offers a cost effective solution for the AAL applications to connect to the internet when required.

5 Related Work

Homecare systems have been researched for several years. There are already a few commercial solutions available. However, several existing solutions rely on call centers and transmit their data through phone lines.

The first established system is well@home, which uses wired sensors to acquire vital data and transmits them via a built-in modem. For wireless systems, a popular approach is the Body Area Network to gather sensor data and the use of a Mobile Base Unit for temporary data storage and data transfer. Often, the latter unit is a smartphone that uses GSM to transmit the data. MobiHealth [3] is a representative of such BAN-based monitoring systems. The Citizens' Healthcare System [4] and several other ECG home devices use the microphones of phones to send the collected data in the form of acoustical signals to the clicnic. The WiPaM [5], Motiva [6], TOPCARE [7], CardioScout [8] and Bluetooth ECG [9] projects use a Home Care Unit to gather data via Bluetooth and then transmit them to a healthcare provider using normal phone or data lines.

Compared to the above systems, our solution merges the best features of them. In our system, the PDA has enough computational power to integrate and process the gathered data like a home unit but it is lightweight enough to be portable like a mobile unit. It needs no wiring either for the sensors nor for the connection to the outside world. And finally, it uses digital data transfer over the internet instead of an analogue one over phone lines.

6 Conclusion and Future Plans

In this paper, we envisioned a PDA-centered medical sensor system setup that is suitable for the AAL homecare scenario. Additionally, we identified a problem (lack of internet access) that can easily arise in rural areas. Then we introduced a pilot application, which is a manifestation of the envisioned system, consisting of a Bluetooth-capable mobile ECG device, an open source platform-based PDA, and a software running on the PDA that extends the ECG device with AAL functionalities. Moreover, the PDA has been equipped with a network layer that can provide internet access even in rural areas in a cost efficient way.

For the future, there are several plans for enhancing the current application. First, we plan to add more medical sensors to the system, and then the application is going to be extended with medical intelligence that integrates the acquired data and takes all of them into account during decision making. Additionally, we plan to cooperate with organizations of rural settlements and Rural Living Labs, thus ensuring the field testing of the application and its enhancement based on the feedbacks. Finally, we are looking for application possibilities of the system not only in the homecare scenario but in other AAL areas as well.

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