Bringing Health Telemonitoring into IPTV Based AMI Environment

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ABSTRACT
In this paper, we describe the development of a personal-health telemonitoring application which is integrated into the Internet television based home communication environment. The application presently enables monitoring of blood pressure and body weight and supports on-line medical interviews. We present the functionality of this application. Its key feature is the user interface, manageable by a simple TV remote-control. The implementation results in a software widget, which is installed in a net-top-box. It builds the user interface, provides monitoring of measurement devices and communications with the back-end systems.

We conducted an evaluation of the overall user experience, which shows very encouraging scores. Beside this, the application enables personal-health service that is comparable to the one, provided by dedicated personal-health systems. At the same time, its open architecture allows for future extensions and simple inclusion of other health monitoring areas.

Keywords
Personal health system, PHS, IPTV, net-top box, NTB, blood pressure, weight, usability evaluation

INTRODUCTION
The emerging information and communication technologies (ICT) can importantly support social-, health- and security-related challenges in a modern society. Ambient intelligence solutions (AMI) are evolving into convergent, multimedia and multipurpose systems. One of possible usage scenarios of AMI are personal-health systems (PHS) [13]. PHS improve healthcare by prevention or remote health monitoring. PHS combined with AMI have an emphatic role for elderly user, because they support ageing well and independent living in their home environments, too [11].

Background on Health and Safety Related IPTV Solutions in AMI Environments
Our research combines several broad technology- and user-related areas. Despite this the intersection is rather specific and narrow.

Important aspects of AMI are health and safety related applications. Although these applications can be valuable for every home user, their importance increases for older adults [1], [7]. There are many examples of successful telemonitoring trials. They are ranging from technologically simple, but clinically thoroughly elaborated observations of small sets of physiological parameters [5] to sophisticated behavioural monitoring of elderly at home [8]. However, not many IPTV systems supporting telehealth services have been reported. The Phillips Moovi [13] is among most frequently applied ones it. It is based on an IPTV platform with telecare and telehealth interfaces built in the STB by the manufacturer. The system has been implemented, among others in a trial conducted by Newham Council and Primary Care Trust [18].
Most currently deployed IPTV systems rely on powerful back-end platforms and simple dedicated user terminals, i.e. set-top-boxes (STB). A STB has usually very limited computational resources, mostly dedicated to the display of the selected TV channel and the creation of IPTV user interface. Introduction of additional services on STB platform is complicated and completely left to the STB manufacturers and IPTV platform developers. With latest developments STBs can be replaced by net-top-boxes (NTB). A NTB offers all the functions found in STB. But NTBs are typically based on personal computer-like hardware platforms and apply derivates of readily available operating system. Introducing new functions into a NTB is therefore much more open and can even bypass the IPTV platform and service providers.

Implementing the support in NTB makes the introduction of telemonitoring in home environments easier. We can decouple the monitoring from IPTV provisioning. Despite this, the NTB is the only additional part of the communication equipment and the telemonitoring remains seamlessly integrated in the TV user-interface. Additional benefit of powerful NTB platform is support for other multimedia and communication features. They can complement telemonitoring with educational material, provide reminders and interactive medical questionnaires or add real-time communication support.

In this paper, we present design, implementation and brief usability evaluation of a personal-health system which is integrated into an IPTV home-environment and implemented in as a net-top-box application. A user applies this system with a plain remote-control and TV-set. These are two devices that most of the intended users are very familiar with. This approach to some extent differs from user terminals in AMI environments, where commonly portable or wall-mounted touch-screens are applied. PHS which is integrated in NTB minimizes new or additional dedicated equipment at the user side. Integrated implementation of a PHS can be thus more cost effective - showing an important additional benefit for ICT service providers.

**System Description**

The personal health solution described in this paper was developed within a wider intelligent-living environment developed at the Faculty of Electrical Engineering, University of Ljubljana. This test environment features an array of services for ambient assisted living, such as home automation control, energy resource consumption monitoring, home alarm control and health telemonitoring. For each service, a set of physical devices such as switches and sensors are installed in the environment. These devices feature various communication interfaces, using which they connect to an integrated communication gateway designed to convert local multi-protocol communication into Internet-like communication standards such as Internet protocol, Simple Object Access Protocol (SOAP) and Extensible Markup Language (XML). In this way, the home environment is connected to a server back-end, which is divided into elements hosting central control on one side and application logic on the other. Users can control the test living environment in various ways. Apart from Web-based interfaces for standard personal computer and mobile clients, IPTV user interfaces for various set-top-box (STB) and NTB platforms were developed.

**Functional Description**

Our aim was to define and implement a personal-health application which is fully integrated into the domestic IPTV environment and is optionally connected to back-end system, responsible for advanced health monitoring services and features.

From the end-user perspective management of the application relies on remote-control and presentation on a TV screen. Its’ use is therefore expected to be equally straightforward and easy for the users as any other TV applications they are already familiar with (e.g. using electronic program guide, browsing for information on the TV). This provides a potential to bring the PHS functionality to users in a new and accessible form (Figure 1).

![Figure 1: User-interface of the IPTV based health telemonitoring system](image)

The current implementation enables blood-pressure and weight measurements with rather common sensors and weight scales that have built-in communication interfaces. The measurement results are automatically read from the device and stored in the NTB. The TV user receives a notification about new PHS data in the NTB interface (Figure 2). Every measurement can be accompanied by a short on-line interview providing the basic medical history relevant for a particular measurement (Figure 3). User can then review edit or delete the existing measurements. The measurement history is presented in a tabular or graphical form (Figure 4).
A background communication service assures simultaneous upload of measurement values and corresponding meta information (e.g. time-stamps, user identifications) to a back-end system. The back-end provides non-end-user features like storage of larger history sets of data, application support for medical staff (e.g. doctors, nurses) responsible for monitoring the patients and integration with medical data exchange systems.

The application has a multi-user support. The same NTB can therefore be used by more than one user (e.g. several family members, habitants of a retirement home). User is authenticated by a PIN or smart card. If the system is used by a single user, authentication steps can be bypassed.

Special attention was devoted to the simplicity of the graphical user interface (GUI). We have taken into account that the application should be easy to use both for average TV users as for elderly people. Various GUI-development guidelines [4] were taken into account, such as usage of large text fonts and images, basic colors and simple navigation, adapted to usage of the remote control. We believe that the GUI is one of key factors for application usability.

Technical Description
The personal-health application was implemented as script application for XBMC Media Center [19]. This NTB-based IPTV solution already comes with basic features, including Live TV, personal video recorder, electronic program guide and various entertainment-, social- and collaboration-based applications. It also provides a framework for deploying additional plug-in applications. This will enable us to add additional e-health features later on.

We have chosen two personal health devices, a blood pressure monitor [15] and a weight scale [16] to work with our application. These devices are equipped with Bluetooth and RS-232 communication interfaces that enable measurement results to be transferred into the application. Other devices, such as spirometer or glucose meter can be also added later on to extend the functionality of the application.

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was designed. To determine the primary user’s subjective assessments of the application’s usability, the system usability scale (SUS) [3] was conducted. Resources in this research project were limited, so the evaluation study required volunteer study participants between 18 and 80 years of age. Fifteen people, twelve male and three female, aged between 25 and 50 years, answered the call for volunteers. Study participants were using the application in a usability lab for a limited period of time (one hour). At the beginning, all study participants were introduced to the personal-health application. Afterwards, every participant was conducting different tasks such as: measuring weight, measuring heart rate, answering medical questionnaires etc. At the end of the user evaluation study in the usability lab, study participants filled in SUS questionnaire.

The average SUS score personal-health application obtained is 68.2 out of 100. With the exception of two very bad ratings (7.5 and 12.5), almost all other ratings for the application are high above the average. Further SUS analysis is needed, which will provide reasons for the two extreme ratings. According to Bangor et al. [1], obtained SUS score means that study participants find personal-health application acceptable and good in terms of usability aspects.

CONCLUSIONS AND FUTURE WORK

The preliminary study of user experience shows that the personal-health telemonitoring application, presented in this paper, provides similar functionality as the dedicated personal-health systems. We plan to repeat the study with a larger target group of older adults and with an equal distribution by the gender. With additional usability evaluation methods we intend to additionally improve the application from user’s point of view.

The application architecture, which is based on open programming and communication interfaces, is easily extendible. Further developments are therefore possible in the open-source community as well as in commercial service provisioning environments. This adequate support for PHS service deployment is of key importance. Successful service provisioning requires cooperation of personal-health system players, IPTV service providers and medical or/and health provisioning institutions. Dedicated, closed and proprietary solutions limit the possibility of such cooperation.

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