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DAQ solution Monitoring Personal Health Monitoring with Android based mobile devices

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Abstract **- We have developed an Android based mobile data acquisition (DAQ) solution, which collects personalized health information of the end-user, store analyze and visualize it on the smart device and optionally sends it towards to the datacenter for further processing. The smart mobile device is capable to collect information from a large set of various wireless (Bluetooth, and WiFi) and wired (USB) sensors. Embedded sensors of the mobile device provide additional useful status information (such as: user location, magnetic or noise level, acceleration, temperature, etc.). The user interface of our software solution is suitable for different skilled users, highly configurable and provides diary functionality to store information (about sleep problems, can act as a diet log, or even can be used as a pain diary). The software enables correlation analysis between the various sensor data sets. The developed system is tested successfully within our Living Lab facility. Sensor data acquisition on the personal mobile device enables both end users and care givers to provide better and more effective health monitoring and facilitate prevention. The paper describes the internal architecture of the software solution and its main functionalities.**

Keywords- **Remote health monitoring, portable sensor data acquisition, mobile device**

INTRODUCTION

The aging population of industrialized countries grows and this increases also among other things the health care costs. Transparently embedded remote health care can become a new cost effective paradigm, which can solve most of the problems primarily centralized Health Care system's have. Currently, there is a large number of enabling technologies to measure the patient's physiological signals remotely. With handheld and PC devices used as data acquisition (DAQ) systems we are able to collect vital information about the (elderly and demented) patients remotely. Due to the different - in most cases proprietary and incompatible- sensor technologies and solutions, it is a hard task to create generic, user friendly DAQ systems. There are already remote patient monitoring solutions available such as the Android based My Fitness Companion [1], which is able to support the following therapy fields: Fitness, Diabetes, Asthma, Obesity, Hypertension, CHD, or the iCare[2] which provides medical guidance, emergency alarm functionality and collects personal health information. Other example is the Microsoft HealthVault [3], which supports care of elderly persons (e.g.: neurodegenerative diseases, stroke etc.), additionally it provides online web interface to manage (process and share) health information. Biotech Lab at Obuda University is involved in AALAMSRK [4] (a national R&D project), specialized both on Android based (we call this MobileHub) portable remote monitoring applications, and normal PC based (we call this

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HomeHub) remote monitoring solutions (shown in Fig. 1.).

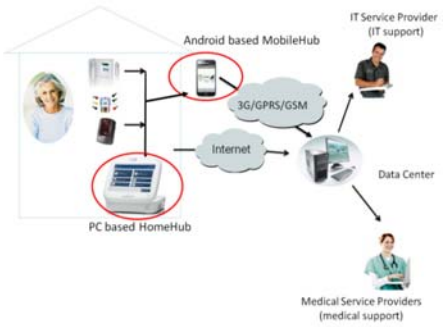

Figure 1. Overview of the remote health monitoring
infrastructure (with PC based HomeHub and Android
based handheld MobileHub collecting sensor data) [9]

This paper shows how we have built up our remote patient monitoring environment (DAQit)[8] using a client side software and the DrHealth portal. Later on we present how this software environment has been used to do patient's location/sudden event monitoring, remote diabetes and hypertension monitoring in our Living Lab. Through the co-operation of commercial companies, universities and other non-profit organizations the direct goal of the AALAMSRK project was to develop an integrated, standardized dementia and health monitoring system supported by innovative, modern measurement and info-communication technologies. By the integration of medical expertise and developing assisted living patterns (ALPs), the realized system offers personalized monitoring solution for monitoring and prevention of elderly people, particularly who suffer from stroke, neurological diseases such as dementia or depression. Our two DAQ solutions (Home Hub and Mobile Hub) are able to serve overlapping patient categories (shown in Table 1.).

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Targeted Patients & persons	PC based HomeHub	Android based MobileHub
Diabetes	Yes	Yes
Hypertension	Yes	Yes
Elderly monitoring	Yes	Yes
Epilepsy	Yes	Yes
Parkinson's disease	Yes	No
Alzheimer	Yes	No
Stroke	Yes	Yes
Movement problems	Yes	No
Obesity	Yes	Yes

Table 1. Targeted patient categories of the two
remote health monitoring solutions (HomeHUB and MobileHUB)

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A. Motivation Considering the real social and market demands and the needs of the health care service provider segment [5], the general project aim is to improve the quality and cost effectiveness of health care services by developing service models, methods, tools, products and services. We are doing research and development of a full scale remote telemonitoring system that monitor both activity levels and vital signs such as blood pressure, blood sugar level and heart rate, alerting caregivers about potential health problems or emergency situations. Service categories of a generic home-based care/remote patient monitoring solution Remote patient monitoring builds up from the following five evitable service pillars:

• Data acquisition services DAQ services collect physiological information of a person's condition from deployed sensor infrastructure or from the person directly.

• Store/forward and visualize services to store, process and visualize locally the captured physiological information of a person's condition at the patient's device and to forward these information using ICT towards the central data collector node for further data processing, storing, visualization.

• Activity recognition services Recognition of psychophysical performance of patients or elderly people for effective therapy intervention (quantitative and qualitative measurement of body movement).

• Behavior monitoring services Recognition of psychophysical performance of patients or elderly people for effective therapy intervention (quantitative and qualitative measurement of high level living patterns).

• Lifestyle guidance services (knowledge transfer) Feedback from medical experts/physicians based on the acquired real-time or historical data enables lifestyle guidance, therapy adjustment, early warning/prevention, personalized health care & rehabilitation.

LIVING LAB INFRASTRUCTURE

Main novelties of the AALAMSRK project are that it brings into the patient's home medical assistance and lifestyle guidance services and also it supports new potential opportunities to capture insight medical knowledge with its effective non-stop health monitoring methods. The monitoring is done by our clinical trialready, standardized distributed monitoring and testing environments (so called Living Labs). Our Living Labs are supporting all the R&D tasks of the medical, engineering and business (marketing) work packages and also provides evaluation and test environment for new hypotheses and results. The established Living Lab environments are located in three different regions within Hungary (capital city, middle size city and rural area), thus the type of patient environments (living space size, accessibility, communication infrastructure, etc.) are totally inhomogeneous [9]. During the test periods -thanks to the Living Lab studies-, we have learned a lot about the different environment requirements, and revealed many aspects of various problems concerning sustainability, usability of our health monitoring and emergency management solution.

FIXED (HOMEHUB) VS. PORTABLE (MOBILEHUB) MONITORING DEVICES

During the AALAMSRK project the PC based HomeHub was firstly developed. The HomeHub framework supports Linux and able to run both on proprietary solutions (like Intel HealthGuide) and on outof-the-box commodity PCs optionally equipped with touch screen. Beside the HomeHub solution, later on we have developed an Android based MobileHub (shown in Fig. 2.) solution as well, which enables additional usage scenarios due to its different (mobile) characteristics.

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Figure 2. HomeHub (on left) with connected sensors and GUI of the Android based MobileHub (right)

We need to note here, that both HomeHub and MobileHub are capable to run on various other hardware configurations. The HomeHub was tested on a large set of (Linux installed and touch screen equipped) PCs with success. According to our tests the MobileHub software is capable to run almost all Bluetooth enabled and Android 1.2+ based Smartphone. We should also note here that even if both solutions working non-stop 7/24, the PC based HomeHub consumes far more power, than the Android based MobileHub. According to our tests the usage of the PC based HomeHub solution requires significant amount of electricity, and the increased electricity costs can become a limiting factor at the number of potential users. A. Actual sensor set of our health monitoring system Sensors can provide digital fingerprint of the patient's/person's psychophysical status and performance. We categorize sensors according to their data collection methods: active or passive type sensors. In our solution we are using a wide range of sensors (both passive and active, shown in Table III.) to collect detailed and accurate information about the patient remotely about:

- patient's blood glucose/sugar level
- patient's actual pulse, and oxygenization level
- patient's ECG signals
- patient's blood pressure
- patient movement within the house, with the usage of wall mounted sensors
- patient medication, with sensors of the medicament dispenser • patient's eating habit, with sensors placed on the refrigerator
- patient activity with so called "Actigraph", which is a watch like sensor on the patient's wrist. Actimetry sensor can measure non-invasively rest/activity cycles, gross motor activity.
- patient's weight
- environmental information, about room temperature, humidity etc. B. MobileHub basic software features
- Health status visualization.
- Multi-language support (English, German, Italian, and Hungarian).
- Silent sensor DAQ mode (automatic data collection) via Bluetooth.
- Health status visualization (with statistics and data mining facility) at the data center.
- Manual DAQ mode (optionally GUI initiated sensor data collection) only via Bluetooth.
- Limited data compression and encryption during data transmission towards the data center.
- Automatic sensor data pre-evaluation at the MobileHub.
- Full featured location aware mobile emergency alarm. • Real-time sensor

data forwarding to the central data collector server
- ❖ Store and forward mode to enable offline data collection.
- ❖ Based on the test results received from the Living Lab experiments- due to the small touch screen-, on the MobileHub multiple separated GUI have been developed for the differently skilled elderly persons.

To overcome all the usage limitation problems, we have identified two user skill sets, which can categorize the hardware/software utilization ability level of the patient: • GUI for elderly persons without any IT knowledge (oversimplified single button type GUI) • GUI for normal and expert end-users the panic button is just an icon and all the in-build additional software/hardware functionalities of a normal Android mobile phone are available (menu sets, SMS, dialing, applications, etc.). Patient can manually initiate sensor management and can manually provide measurement inputs on the GUI (shown
in Fig. 5. and Fig.6.).

C. Mobile Hub additional software functionalities

1) Location and sudden event monitoring service In a sudden panic situation an alarm can be activated manually (by the patient) or automatically (by e.g. the accelerometer) with the mobile device. When an alarm signal initiated the central dispatcher is able to acquire location information (based on GPS and GSM/GPRS cell information) immediately. The automatically established two way voice communication can help to understand the context of the sudden event. The Mobile Hub can work as a location independent, always-on personal emergency notification device.

2) Diary / reminder services Besides pure data collection our MobileHub enables to do correlation analysis of stored data series. Reminders are intended to notify user in pre-defined appointments about data collection needs. This feature enables to track data in certain periods like measuring patient's blood glucose level on a regular basis

CONCLUSIONS

During our almost 4 years long development period both the fixed and portable solutions have been rigorously tested in the LivingLab environment. Beside patient monitoring we had to monitor remotely not only the patient's status, but also some mobile hardware and software specific parameters (such as: battery level of sensors), and we had also to redesigned the whole user interface of the handheld device to support elderly persons with low IT skills. According to the received result both our PC and Android based DAQ solutions are capable to provide seamless remote monitoring of elderly persons not only at home, but with MobileHub also abroad. The developed solutions provide important feedbacks about health status to the patient and to the medical experts.

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