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The MyHealthService Approach for Chronic Disease Management Based on Free Open Source Software and Low Cost Components

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Abstract—**In this paper we present an approach to building personal health services, supporting following-up, physical exercising, health education, and psychosocial support for the chronically ill, based on free open source software and low-cost computers, mobile devices, and consumer health and fitness devices. We argue that this will lower the cost of the systems, which is important given the increasing number of people with chronicle diseases and limited healthcare budgets.**

I. INTRODUCTION

THE number of people with chronic diseases is increasing rapidly worldwide, and according to the World Health Organization chronic diseases are now the major cause of death and disability in the world [1]. Also, the age structure in the population is changing, people live longer and the prevalence of chronic conditions increases with age. This represents a major challenge for the healthcare systems, both in terms of personnel and cost.

New and innovative technologies and services may have a potential for supporting prevention, treatment and following up of chronically ill in the home environment, while keeping the costs low. In MyHealthService we develop inexpensive and flexible technological solutions for people with chronic diseases based on low cost PC's, mobile computers, consumer health and fitness devices, and Free Open Source Software (FOSS). We are exploiting the following trends in software development and the consumer market:

1) An increasing availability of small, silent and powerful mini desktop computers that are suitable for homes.

2) A wide availability of internet enabled smart phones and mobile computers.

3) The popularity of gaming consoles and devices for exercising have brought into the market a range of motion sensing devices, and demonstrates that technology based exercising can be both fun and social and have potential for being used in rehabilitation [2].

4) The FOSS community provides access to a wide repository of software components that can be customized and used for personal health services.

We focus on systems and services that improve the self management skills of the chronically ill and promote an active lifestyle, and where the health personnel have a supportive and guiding role. We have developed home-based services for the following-up, physical exercising, health education, and psychosocial support for the chronically ill, including Chronic Obstructive Pulmonary Disease (COPD) and diabetes [3].

This paper elaborates our approach for developing low cost personalized health services based on FOSS and low cost computers and consumer health and fitness devices.

II. MYHEALTHSERVICE APPROACH

A. The patient environment

A central component in our patient environment is the Residential Patient Device. It provides secure communication between the chronically ill and the healthcare personnel, and between peers. It contains a personal health diary, educational resources, and other vital functions needed to support integrated services in the patient environment.

Services will be available on one or more patient devices, and the user will chose the most appropriate one depending on the situation, and needed functionality.

Patient health and fitness devices like medical sensors, motion tracking devices (wireless accelerometers and IR cameras) and sensors embedded in fitness devices (such as boards, blankets, stationary exercise bikes) are used to support a rich set of services.

The system software is mainly constructed from Web-based FOSS components[1] on computers running Linux. Additionally, we are incorporating other web-based components, such as Indivo open-source Personal Health Record [4] and a personalized questionnaire management system.

Information security measures implemented encompass encryption, authentication and automatic logout. Risk assessment has been performed in order to fulfill the Norwegian legislation on procession of personal data, which is based on the corresponding European directive on the

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[1] The first Patient TV Device had an Firefox as application interface, Apache Tomcat for application server, Postgres for data storage, openVPN for secure communication, Ekiga for videoconferencing, and Xine for video playback.

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protection of personal data [5].

B. Patient devices

Figure 1 below shows the patient devices in MyHealthService; TV, Mobile and Touch devices, and the health and fitness devices.

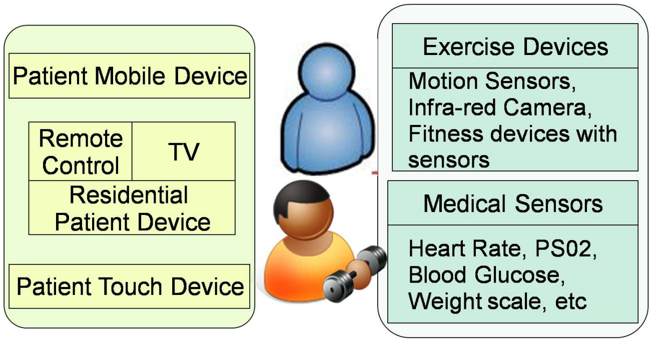

Figure 1. Patient devices and sensors

The choice of patient devices for a specific service will depend both on the service in question, user preferences and context. A live training session under supervision of a physiotherapist may be most preferable on a large screen, while the patient health diary can be viewed on the TV at home and on a mobile device while on the move.

Fig 2. Patient TV Device

The *Patient TV Device*, in figure 2, includes a TV and a dedicated remote control, connected to the Residential Patient Device. The TV device was originally introduced into the patient environment in order to also reach those who have limited computer skills. But, this is not the only reason, as there are services most suitable on a large display.

The *Residential Patient Device* was first implemented on a Barebone PC, then a Mac Mini, and latest on an ASUS Eee Box mini desktop computer, all running Linux.

Figure 3. Patient Mobile Device

The *Patient Mobile Device*, figure 3, is intended for usage both at home and while on the move. It is implemented on the Nokia 810 touch sensitive internet tablet, a Linux-based Ultra Mobile PC. It has a camera, microphone, built in GPS, keyboard, Wi-Fi and Bluetooth.

Figure 4. Patient Touch Device

The *Patient Touch Device*, figure 4, is an all-in-one PC with a touch sensitive LCD display and built-in camera, microphone and speakers. It is a wireless unit that can be deployed flexible around in the house. It is implemented on the ASUS Eee Top running Linux.

The *Patient Exercise Devices* incorporates consumer fitness devices such as video gaming controllers (WiiRemote [6] and WiiBoard) and motions sensors (Inertia ProMove[7]) for tracking and supporting the performance of the physical exercises. The WiiRemote is one of the cheapest devices having an IR Camera, 3D Accelerometer, vibration and speaker, and future versions will also include a gyrometer. Additionally, it has a communication protocol supported by multiple FOSS modules and APIs.

Unfortunately, there are not many consumer health devices with Open Protocols and APIs available. In most cases the consumer oriented health monitoring devices are proprietary and closed. However, this tendency is shifting due to several initiatives towards standardization and open protocols, such as the Continua Health Alliance[2]. Currently we have integrated several wireless pulse oximeters from Nonin Medical Inc and a glucometer from LifeScan Inc.

The wireless sensors and devices incorporated are communicating using the Bluetooth standard, who has the advantaged of being widely available in multiple devices. However, we are also looking into incorporating wireless sensors using the low-power ZigBee standard.

C. Services

Table 1 gives and overview of the current status of the four service categories (health diary, health education, exercising and community), their implementation on patient devices, and evaluation.

Early versions of all categories of services have been field trialed using the Patient TV Device for patients with COPD (a comprehensive home-based rehabilitation program) and diabetes (group based education and individual following-up

[2] www.continuaalliance.org

at home) [3,8]. The results showed high usability of the system.

Most of these services have already been ported to the Touch and Mobile Devices. New exercise services, such as Virtual Worlds for group based exercising, are now being developed. These are also described in the following sections.

D. Health Diary

The patient health diary contains disease related questions, vital sign measurements such as oxygen saturation, heart rate, blood glucose values, and activity registration.

The disease related questions have predefined answers the patients can choose among. The oxygen saturation and heart rate can be filled in manually or transferred wireless from the sensors to the patient devices. The health diary is currently available on TV, and has been field trialed for both COPD and diabetes. On the Touch and Mobile devices it is available for COPD only, and ready for trial with patients.

E. Health and lifestyle education

People with chronic diseases need to learn how to manage their diseases in order to improve their self-management skills, and they often need to modify their lifestyles. A service for group based education at home, including the use of educational videos and live educational sessions, has been field trialed for both COPD and diabetes using the Patient TV Device [3,8].

We are extending our system to incorporate web-based content for health education. On the Web there is a huge amount of health information and educational material available, and the challenge is to identify the relevant information. In order to address this problem a flexible and adaptive recommender system for web-based health educational materials, called MyHealthEducator, is being developed for all three patient devices. The recommendations will be based on knowledge acquired from the web, the patient health diary and also from a virtual community with peers [9].

F. Exercising and activity

Physical exercises are important for patients with chronic diseases [10,11], and exercising can decrease symptoms on depression and sleeping problems, which are common problems for people with for example cardiac and pulmonary diseases. Lack of motivation is a problem in order to sustain an adequate level of physical exercising; the problem could be approached by combining social exercising and games.

Group-based exercises on TV under supervision of a physiotherapist have been field trialed with COPD patients [3,8]. In addition, the patients also had an instructional and follow along exercise video available on the TV. Exercising services based on the Wii Remote are currently being developed. An interesting aspect is the combination of physical exercising, Virtual Worlds and sensors for enhancing the social dimension, which is an important issue

TABLE I
SERVICES DESCRIPTION

Service	Description	Components/Status [a]
Health Diary	Questionnaires integrated with wireless/wired sensors	Patient TV Device (TP) Patient Touch Device (TL) Patient Mobile Device (TL) Medical Sensors (TP)
	Context-aware questionnaires integrated with wireless/wired sensors	Patient TV Device (UD) Patient Touch Device (UD) Patient Mobile Device (UD) Medical Sensors (UD)
Health Education	Individual and group based videoconference education	Patient TV Device (TP) Patient Touch Device (TL)
	Educational videos	Patient TV Device (TP) Patient Touch Device (TL) Patient Mobile Device (TL)
	MyHealth-Educator: recommendations of educational materials based on the patient's health record and the user's community	Patient TV Device (UD) Patient Touch Device (UD) Patient Mobile Device (UD)
Exercising	Individual and group based physical exercising with videoconferencing	Patient TV Device (TP) Patient Touch Device (UD)
	Virtual Reality training club with motion tracking	Patient TV Device (UD) Patient Touch Device (UD) Medical Sensors (UD) Fitness Sensors: sensors embedded in fitness devices (boards, blankets), wearable motion sensors, IR cameras +LEDs (UD)
Community	Video-conferencing and messaging	Patient TV Device (TP) PatientTouch Device (LT)
	Virtual communities & Web 2.0 tools: chat, forums, blogs, video-logs, virtual world	Patient TV Device (UD) Patient Touch Device (UD) Patient Mobile Device (UD)

[a] Development Status: TP = tested with patients, TL = Tested in Lab; UD = Under Development

in our target group. Our focus is on the social enhanced exercising, and not on collecting medical relevant information about the patient for the healthcare personnel [12-14].

G. Community tools

The group-based education for COPD on TV, described briefly earlier, also incorporated a social dimension, giving the participants the possibility to meet and discuss with peers on a regular basis for a longer period of time.

Web 2.0, the Social Web, and Virtual Worlds provide new possibilities to enhance the social interaction among patients. Currently, we are investigating the use of User Generated Content (such as videos) for educational and emotional support among peers. Additionally, we are developing a Virtual World based on Wonderland, which will be used to enhance the social aspects by means of group-based learning and exercising. The Virtual World is under development for the TV and Touch Device.

III. DISCUSSION, CONCLUSIONS AND FUTURE WORK

The use of FOSS, low cost computers running Linux, and health and fitness devices with open protocols have made it possible to rapidly develop and demonstrate new functionalities and services.

However, bringing the prototypes out of the laboratory and into real life usage depend on more factors. Many do not use FOSS based systems, as there is a lack of organizations or commercial companies who take responsibility for such systems, providing integration, training, and support.

However, the potential in healthcare should be large, as most healthcare institutions have skilled technical ICT departments that would be capable to adapt a system to the specific needs, do systems integration, support and training – in addition to contributing to further development of the FOSS solution.

Availability of health and fitness devices with open protocols are still limited. Many interesting medical and motion sensors are developed by companies that only provide the devices as part of a proprietary service, where the device specifications and protocol is closed. However, the Continua Health Alliance and several other initiatives are working towards standardization and open protocols within healthcare, work we benefit from by integrating these devices and protocols in our environment.

Our aim is to continue developing systems to help improve the self management skills of the chronically ill. Further work includes the support of new patient devices, and improving the services, especially for physical exercising and social interaction in order to increase motivation and reduce social isolation.

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