The MyHeart Project: A Framework for Personal Health Care Applications

M Harris, J Habetha

Philips Research, Aachen, Germany

Abstract

MyHeart is a so-called Integrated Project of the European Union aimed at developing intelligent systems for the prevention and monitoring of cardiovascular status. The approach of the MyHeart project is to monitor Vital Body Signs (VBS) with wearable technology, to process the measured data and to give the user (therapy) recommendations from the system. Using its broad base of technical and business expertise, four concepts adressing cardiac health have been developed and tested on a technical, business, realisability and usability level.

1. Introduction

Cardiovascular disease (CVD) is the leading cause of death in developed countries. Roughly 45% of all deaths in the EU, and 37% in the U.S. are due to CVD [1]. Hundreds of billions of euros are spent worldwide each year on the treatment of CVD. In order to maintain and improve the quality of heath care without exploding costs, heath care systems are undergoing a paradigm shift from patient care in the hospital to care at home.

A healthy and preventive lifestyle as well as early diagnosis of heart disease could save millions of life years annually, simulataneously reducing the morbidity and improving patient quality of life. Prevention offers the opportunity to systematically fight the origin of cardio-vascular diseases as well as to improve the medical outcome after an event. To enable a preventative health care system, a move is required from the current, intermittent episodical treatment to continous and ubiquitous access to medical excellence. Novel methods are needed that provide continuous and ubiquitous access to medical excellence in a cost-effective way.

It is the aim of the MyHeart project to fight CVD by prevention and early diagnosis. This is done by monitoring Vital Body Signs (VBS) with wearable technology, processing the measured data and giving (therapy) recommendations to the user of the system. Using the measured data to give user feedback 'closes the loop' of measurement and therapy. As illustrated in Fig. 1, this closed loop can either consist of direct local feedback to the user or of professional help by a physician or nurse. The latter will typically be provided remotely, which implies that the MyHeart system also comprises a telemedical element. Data are transmitted to a remote server, where a professional can access the data and contact the patient subsequently.

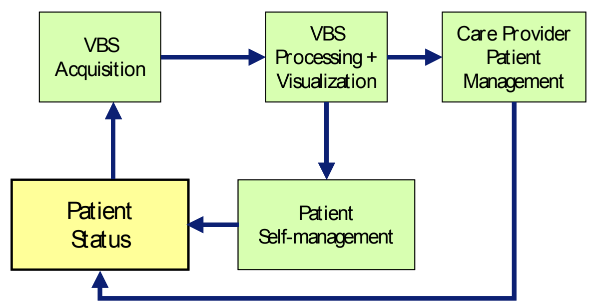

Figure 1: MyHeart disease management and prevention approach

The system can be used for helping people to lead a healthier life as well as for the improved management of chronic diseases.

2. Consortium and project overview

The *MyHeart* consortium [2] involves 33 partners from 10 different countries. It is a balanced multidisciplinary consortium of industry (including Small and Medium Enterprises (SMEs)), research institutes, academia and medical hospitals. Prominent industrial partners are Philips, with its medical and technological expertise, Vodafone (Foundation) as a leading service provider, and Medtronic, a world-leader in cardiac technology.

The project started in January 2004 and has a total duration of 45 months (until September 2007). It is one of the largest biomedical and healthcare research projects in the European Union with a budget of about 35 million Euros.

The project brings technical capabilities in functional clothing, on-body electronics, user interaction, professional interaction, and algorithmic development together with the business assessment and development capabilities necessary to bring new health technologies to the health care system.

The technological needs for *MyHeart* applications span a wide range covering: monitoring of vital signs (ECG, respiration, activity, etc.); body-worn, low-power, mixed-signal hardware which runs algorithms for detection of health status and prediction of acute cardiac events; user interfaces for citizens and medical professionals; low-power wireless links and server architectures for data handling at professional sites.

3. The concept approach

MyHeart has taken a very innovative approach in ensuring the applicability of the project results in the real world. The consortium has started with a set of application ideas and only afterwards investigated the necessary technologies in order to serve these applications.

A *concept* is a concrete CVD application tailored to a specific user group or customer segment. The MyHeart project began with 16 concepts.

In the first one and a half years of the project, the 16 application concepts worked on answering the following questions in detail:

- **What** is the application/value proposition?
- **Who** are the customers and how to address them?
- **How** to do it technically?
- **Why** to believe in the concept (from medical, technical and economical points of view)?
- **Where** is the business?

In mid 2005, 4 of the 16 concepts were selected for further development in the remaining two years of the project. The criteria for selecting or combining concepts were:

- Medical credibility and feasibility (as perceived by medical professionals)
- Technical credibility and feasibility (also regarding manufacturability)
- Business credibility and feasibility (subdivided into core value proposition, user experience, user interaction, and business model aspects)
- Critical project success factors (like size and excellence of the consortium)

The selected product concepts cover four major user segments: the healthy (Activity Coach), thoas at risk for developing CVD (Take Care), sufferers from a cardiac event (Neurological Rehabilitation), chronically ill people (Heart Failure Management). In the following sections, the four product concepts are presented.

4. Activity coach

The value proposition for the Activity Coach is to empower and allow the end user get maximum benefit from regular exercise sessions, both in terms of pleasure and health impact, anywhere, anytime through giving professional, easy to understand coaching which is tailored to the user's profile, goals [3] and personal performance.

The target group is people exercising for fitness and fun.The activity coach will help guide and motivate this group, both in the fitness studio and outdoors to give them optimal exercise result for the effort given.

As shown in Figure 2, the system consists of four main components:

The **Body Signal Sensor (BSS),** integrated into a textile garment, is responsible for monitoring the required vital signals. A one lead ECG is used to derive the heart rate. A stretch sensor is used to measure respiration rate. Furthermore, an accelerometer is used to measure the step rate while running.

The **Fitness Coach Bike (FCB**) is an indoor bike with integrated sensors measuring the pedaling rate, a processing and communication unit, and a user interaction device.

The **Personal Mobile Coach (PMC)** is a device for the outdoor scenario. It receives data from BSS via BlueTooth and generates appropriate feedback and interacts with the user and the service centre.

The **Fitness Coach Service Centre (FCSC)** is the professional platform that provides online services to the user. It receives all the data from the session, processes it using algorithms for fitness status assessment and performance analysis, and stores all the results. It also provides a web-based interface through which professional users are able to access different functionalities such as session results visualisation, messaging services, or the training program schedule.

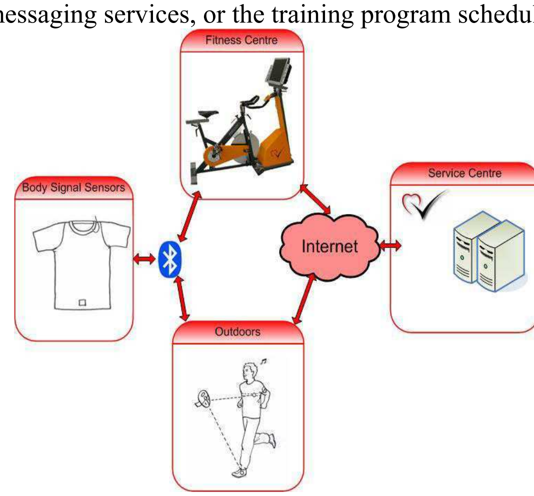

Figure 2: Architecture of the Activity Coach System

During exercise, body and exercise equipment sensors measure heart rate, respiration rate, temperature and step or pedal rate. The data is processed by personalised algorithms, and user feedback is given on the FCB and the PMC. When using the FCB, the level of exercise can also be adapted automatically, guiding the user through the exercise. The system coaches and motivates the user to continue the trainings plan, and creates an immersive environment.

5. Take care

The value proposition of Take Care is to empower the user to change her lifestyle by assessing CVD risk factors and providing appropriate improvement plans and personalised recommendations [4-6].

By providing reliable and trusworthy education, monitoring and coaching, the Take Care system aims at supporting the user to learn and listen to her own body, reducing the risk factors for CVD. The Take Care system is aimed at healthy users that have risk factors for CVD that are willing to spend money out of their own pocket for help in adpoting a healthier lifestyle.

As shown in Figure 3, the Take Care user interaction (UI) device is at the centre of the Take Care system. It is the platform for giving feedback and receiving input from the user, receiving input from sensors, and running personalised algorithms. To initialise the system, initial user data from a weight scale, a blood pressure meter and a cholesterol meter are inputted into the UI device and used to automatically generate a risk profile and lifestyle plan. The UI device then controls and communicates with the measurement devices, following a daily routine. It receives vital body signs (heart rate, respiration rate and activity level) from the on-body electronics connected to textile sensors, and sleep quality data from piezo and textile electrodes integrated into the bed. The data is processed on the UI device, which then gives feedback and coaching to the user. The UI device can also forward the data to a professional centre for further examination.

Figure 3: Architecture of the Take Care System

6. Neural rehabilitation

The value proposition of the Neural Rehabilitation concept is to enable early intensive rehabilitation for patients following a cerebrovascular event [7-8] by using telemonitoring system using wearable technology, speech therapy tools, learning tools and communication tools.

The main users are patients with stroke symptoms, physicians, physiotherapists, and occupational therapists.

The system consists of three main stations (the patient station, the therapist station, and the server site), and the communication structure between them.

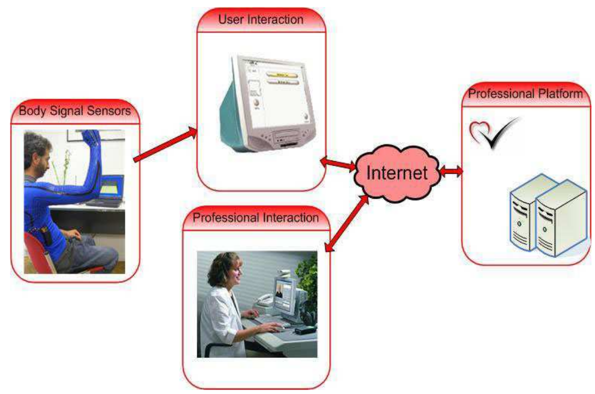

Figure 4: Architecture of the Neural Rehab System

The **patient station**, connected to the therapist station, the server site and the user sensors, is the user interface with the patient, giving feedback on the exercises carried out. Wearable electronics integrated into an upper torso garment is used to monitor the patient movement during rehabilitation exercises. A speech therapy unit is used to carry out and evaluate speech exercises.

The **therapist site** is used by the physician to monitor the patient's exercises and progress. At present, the therapist can only monitor the patient exercises offline. In the future, online monitoring could be possible.

The **server site** is a central server that hosts a database of configurations, exercises, session recordings, demographic data, and the rehabilitation protocol. The physician may access the server through the therapist site to configure the treatment for a particular patient, or to view the recorded data.

7. Heart failure

The main objective of the Heart Failure Management concept is to improve the outcome of heart failure patients with respect to mortality, morbidity and quality of life [9-10]. This objective is achieved by monitoring vital body signs that are relevant for heart failure on a daily basis (currently these parameters are only measured at infrequent visits to the physician) using easy to use equipment in the patient's home. The data is automatically analysed in order to detect changes in the patient's health status early enough to allow early therapy intervention, thus avoiding severe deterioration and hospitalisation.

The end users of the system are patients with heart failure (NYHA classes II-IV), and the physicians and nurses caring for the patient. Typically, the system would be funded by disease management organisations (DMO) and health care insurances.

The user interface for the heart failure concept is a PDA. Like in the Take Care concept, it is the platform for giving feedback and receiving input from the user, receiving input from sensors, and running personalised algorithms. The PDA controls and communicates with the measurement devices. A textile vest with integrated textile sensors and wearable electronics is used to measure vital body signs relevant for heart failure management. ECG sensors incorporated into the bed sheet and pillow, and a piezo sensor under the sheet capture ECG, breathing and movement data during the night. A weight scale and blood pressure cuff send their measured values to the PDA using Bluetooth. The PDA uses personalised algorithms to process the measured data, and to detect a possible deterioration in the patient's health status, triggering action by the patient or medical professional.

The PDA also communicates with a professional platform which receives preprocessed patient data and gives health care professionals access to the application configuration, and the patient's data.

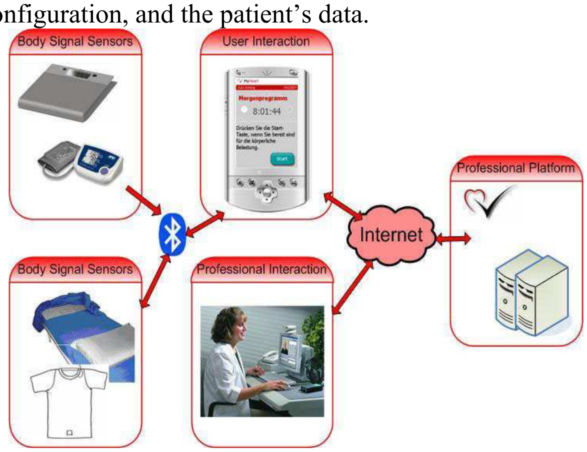

Figure 5: Architecture of the Heart Failure System

8. Validation

Medical and technical validation, and business assessment are important aspects to be addressed by each MyHeart concept. In each concept studies are being carried out with prototype systems with end users to assess usability and medical effectiveness. For the Heart Failure concept an observational study with 200 heart failure patients will be carried out in Germany and Spain. In this one year study, the heart failure system will be used to make daily measurements of vital body parameters. At the end of the study, medical incidents will be correlated with the measured data to deduce which (combination of) parameters can be used to give warnings of a forthcoming decompensation.

Acknowledgements

This work was supported in part by the IST-2002-507816 MyHeart Project.

References

[1] Thom T et al. AHA Statistical Update. Heart Disease and Stroke Statistics - 2006 Update Circulation. 2006;113:e85-e151

[2] MyHeart IST-2002-507816 project (2004). Information available on http://www.cordis.lu/ist

[3] Dunn A et al. Comparison of Lifestyle and Structured Interventions to Increase Physical Activity and Cardiorespiratory Fitness. 1999. JAMA 28:327

[4] Duchna HW et al. Sleep Disordered Breathing and Cardio and Cerebrovascular Diseases: 2003 Update of Clinical Significance and Future Prospectives. 2003 Somnologie 7: 101-121

[5] Lifestyle and Risk Factor Management and Use of Drug Therapies in Coronary Patients from 15 Countries – Principal Results from EUROASPIRE II. 2001 European Heart Journal 22: 554-572

[6] Gordon NF et al. Getting Risk Factors to Goal: Lifestyle Intervention is Worth the Effort in Patients With Hypertension, Hyperlipidemia and/or Hyperglycemia. 53rd Annual Scientific Sessions of American College of Cardiology. 2004, New Orleans.

[7] Sulch D et al. Randomized Controlled Trial of Integrated (Managed) Care Pathway for Stroke Rehailitation. 2001 Stroke 31:1929-34.

[8] Micieli G et al. Guideline Application for Decision Making in Ischemic Stroke (GLADIS) Study Group. Guideline Compliance Improves Stroke Outcome: A Preliminary Study in 4 Districts in the Italian Region of Lombardia. 2002 Stroke: 33(5) 1341-7.

[9] Swedberg K et al. Guidelines for the Diagnosis and Treatment of Chronic Heart Failure: Executive Summary (Update 2005): The Task Force for the Diagnosis and Treatment of Chronic Heart Failure of the European Society of Cardiology. 2005 Eur Heart J:26 1115-1140

[10] Stewart S and Blue L (Ed.). Improving Outcomes in Chronic Heart Failure, 2001, BMJ Books

Address for correspondence
Matthew Harris
Philips Research Labs
Weisshausstrasse 2,
52066 Aachen,
Germany.
matthew.harris@philips.com