The MyHeart Project – Fighting Cardiovascular Diseases by Prevention and Early Diagnosis

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Abstract— **MyHeart is a so-called Integrated Project of the European Union aiming to develop intelligent systems for the prevention and monitoring of cardiovascular diseases. The project develops smart electronic and textile systems and appropriate services that empower the users to take control of their own health status.**

I. INTRODUCTION

CARDIOVASCULAR diseases (CVD) are the leading cause of death in developed countries. Roughly 45% of all deaths in the EU are due to cardio-vascular diseases. More than 20% of all European citizens suffer from a chronic cardio-vascular disease. Europe spends annually hundred billion Euros on CVD. With the ageing population, it is a challenge for Europe to provide its citizens with healthcare at affordable costs.

It is the aim of the MyHeart project to fight CVD by prevention and early diagnosis. A healthy and preventive lifestyle as well as early diagnosis of heart diseases could save millions of life years annually, reduce the morbidity significantly and, simultaneously, improve the quality of life of the European citizen. Prevention offers the opportunity to systematically fight the origin of cardio-vascular diseases as well as to improve the medical outcome after an event. Prevention is therefore believed to be the solution for improving the quality of care for cardio-vascular diseases.

Classical medical institutions offer only intermittent, episodical treatment, while prevention asks for a lifelong continuous change of habits and therefore for a continuous health-care delivery process. The institutional points of care cannot provide preventive healthcare in a cost-effective manner due to their inherent cost structure. Novel methods are needed that provide continuous and ubiquitous access to medical excellence in a cost-effective way.

The approach of the MyHeart project is to monitor Vital Body Signs (VBS) with wearable technology, to process the measured data and to give (therapy) recommendations

to the user of the system. The key element is a closed loop approach, which does not only monitor patients but also provides solutions for the user. 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.
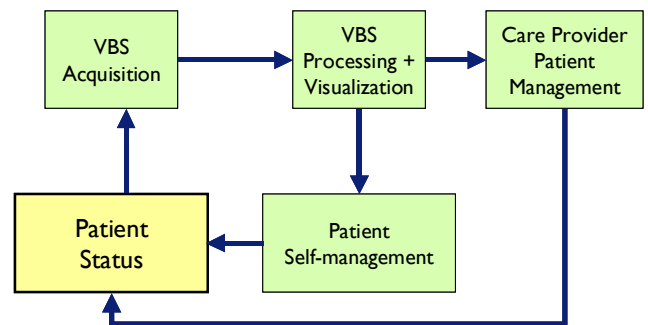

Fig. 1. MyHeart disease management and prevention approach

The system can be used for helping people to lead a healthier life as well as for the improved management of chronic diseases. Such a system has the potential to modernize the healthcare system and to enable it to cope with the future demographic challenges.

II. CONSORTIUM AND PROJECT OVERVIEW

The *MyHeart* consortium 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, Nokia as a leading mobile device manufacturer, 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 Euro.

The project is structured in 8 work packages, as shown in Fig. 2. The biggest work package is dealing with application concepts and associated personalized algorithms. Four technical work packages are researching and delivering the necessary components for the application work package based on the application requirements. The four technical work packages are dealing with

- Functional Clothes,
- On-body Electronics,
- User Interaction,
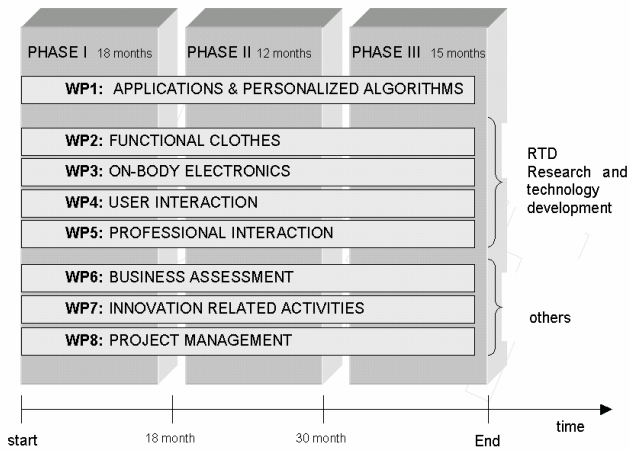- Professional Interaction.

Fig. 2. MyHeart work packages and project phases

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.

One *MyHeart* work package is entirely devoted to business assessment and development.

III. CONCEPT-BASED INNOVATION 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. In a new research field like "Personal Healthcare" it first had to be understood which applications are of highest medical and commercial interest.

Within *MyHeart*, the CVD application field has been clustered into five major areas, each area representing a prominent risk factor for developing CVD:

- *CardioActive: Reduce inactivity*
- *CardioSleep: Improve sleep quality*
- *CardioRelax: Reduce stress*
- *CardioBalance: Reduce overweight*
- *CardioSafe: Reduce morbidity by early diagnosis*

Within this field 16 autonomous application projects called *concepts* have been defined at the beginning of the project. Concepts have been CVD applications tailored to a specific user group or customer segment (Fig. 3). The user base included people who want to stay healthy, people with a recognised risk for developing CVD, chronically ill people and people who have suffered from a cardiac event. The 16 application concepts have been:
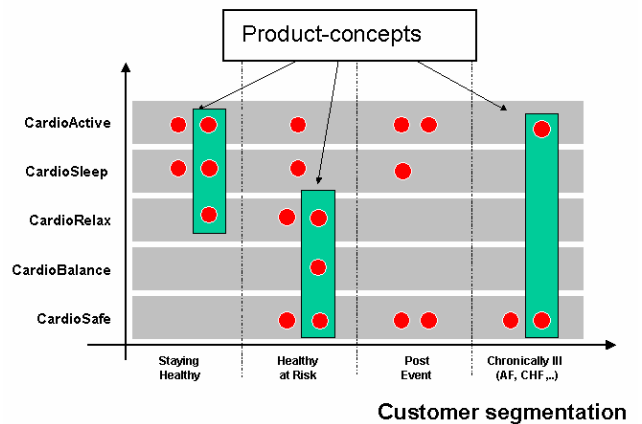

Fig. 3. MyHeart application concept matrix.

- *Virtual Trainer:* Assessment of physical performance and assistance with personalized training plans,
- *Prevention Manager:* Guidance and motivation of runners with adaptive music to sport at a pace that is most effective for your health,
- *Outdoor rehabilitation*: Solutions for different outdoor activities (e.g. biking, walking) tailored and personalized for rehabilitation needs,
- *Sleep & Care CHF Management:* Early detection of decompensation of CHF patients by daily measurements during sleep,
- *Stroke rehabilitation*: Interactive stroke rehabilitation program to improve motor control physical performance,
- *Sleep disorders:* Assessment of sleep quality, early diagnosis of sleep disorders and

improvement of sleep quality,

- *Depression Management:* Early diagnosis of recurrence of depression on the basis of vital body signs measurements at night and day,
- *Cardio Relax 1:* Stress relaxation for consumers based on biofeedback (HRV, breathing) and audio-visual experiences,
- *Cardio Relax 2:* Stress management for post-event patients,
- *Myocardial Infarction prevention*: Early detection of ischemic events based on haemodynamic indicators,
- *Stroke Prevention:* Prevention of atrial fibrillation (AF) induced strokes by early detection and treatment of AF episodes,
- *My HF-web Risk Monitor:* Detection of early indicators for pump failure and directing the user to institutional points of care,
- *Obesity management:* Providing obese adolescents with monitoring services and tools that help them to lose weight, reduce their cardiovascular risk, reintegrate into a social network and rebuild confidence,
- *Hypoglycemic Shock Prevention:* Prediction of hypoglycemic events by continuous measurement of vital parameters,
- *Post Intervention Follow-up:* Early detection of evolving life-threatening risks associated with (i) prosthetic heart valve dysfunctions and (ii) Sudden Cardiac Death due to ventricular arrhythmias,
- *Interactive Exercises:* Interactive system for learning or improving sports techniques by means of motion detection with a sensing garment.

Each concept team comprised a clinical partner, to guarantee medical excellence.

In the first one and a half years of the project, the 16 application concepts have been worked out in detail. In this process each concept has answered five questions:

- **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?

IV. CONCEPT SELECTION AND ONGOING ACTIVITIES

The testing and interview phase with users as well as medical and business professionals in the second project year (2005) has led to a concept selection in mid-2005, during which 4 out of the 16 application concepts have been selected for further research and development in the remaining two project years. The criteria for selecting or combining concepts have been:

- 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 four selected product concepts have been defined in a way that they cover the four different user segments:

- Healthy people
- People at risk
- People after an event
- Chronically ill people

The four product concepts that have been defined for these four groups are:

- "Activity Coach": Making the most of your exercise both in terms of pleasure and health impact, anywhere, anytime.
- "Take Care": Assessing and lowering your risk factors for cardiovascular diseases by vital signs monitoring as well as coaching and motivation.
- "Neuro Rehab": Improving and shortening of the rehabilitation process (motor and cognitive exercises) in the rehabilitation ward and in the patient's home.
- "Heart Failure Management": Improving quality of life and life expectancy of heart failure patients by early prediction of decompensation and improved patient (self-) management.

All concepts have in common the use of on-body sensors and electronics for monitoring of vital signs or movements.

Until September 2006 the prototypes for the four product concepts will be implemented and produced in quantities of dozens or hundreds (depending on the concept). In the last year of the project from October 2006 until September 2007, these prototypes and the associated concepts will be evaluated in extensive user test campaigns. These real-life studies will give important insights into the usability of the concepts and will demonstrate the effectiveness of the solutions.

V. EXPECTED RESULTS & IMPACT

With long-term test beds, MyHeart will show how users employ the system over months and the success will be documented in terms of adaptation of healthier life-style and early prediction of acute events. The results will be benchmarked against clear outcome parameters.

In addition, the project will assess the cost benefits for the stakeholders in the healthcare delivery system. The final outcome will include documented test beds showing the effectiveness and efficiency and the design of business propositions for exploitation of the results. The consortium intends to publish the findings with the aim of establishing this healthcare delivery process into the medical guidelines for treatment ensuring worldwide access to the outcome of the project. Additionally, business to consumer approaches will be evaluated to ensure that anyone can access the solution before general reimbursement can be achieved with the national healthcare systems.

Several MyHeart partners have commercial interests in the exploitation of the project results. Partners like Philips or Dr Hein are working on platforms for telemedical services. A consortium of Italian textile companies within MyHeart is working on the industrial manufacturability of the textiles. Other partners are potential suppliers, e.g. for the electronics modules. The composition of the consortium and the relevance of the applications maximize the chances that the project results will be transferred into commercial products and will thereby become accessible to users across the globe.

On the scientific side, the project has already generated more than a hundred papers, e.g. [1-8], which have been published in scientific journals or presented at conferences. Beside the technical and conceptual papers that are being published, it is foreseen to publish the medical findings of the user and patient studies of the last project year in medical journals.

VI. Overview of the MyHeart Session at EMBC

MyHeart has contributed several papers to EMBC 2006 out of which five have been grouped into a mini-symposium. Beside this overview paper, the MyHeart symposium will comprise two papers regarding the current MyHeart application concepts as well as two papers by the technical work packages of MyHeart.

This overview paper will be the first paper of the mini-symposium.

The second paper "Innovative Concepts for Prevention and Disease Management of Cardiovascular Diseases" by Sergio G. Guillén, Pilar Sala, Joerg Habetha, Ralf Schmidt and Maria-Teresa Arredo contains an overview of the four product concepts selected by the MyHeart consortium.

The third paper "Analysis of sleep and stress profiles from biomedical signal processing in wearable devices" by Sergio Cerutti, Anna M. Bianchi and Harald Reiter gives some more details of the algorithms that are being developed for one of the product concepts called "Take Care".

The fourth paper "Advances in textile technologies for unobtrusive monitoring of vital parameters and movements" by Rita Paradiso and Danilo De Rossi will describe the advances that the MyHeart consortium has made in the area of textile vital signs monitoring.

The fifth paper "User Interaction Design and Development of a Heart Failure Management System based on Wearable and Information Technologies" by Elena Villalba, Maria-Teresa Arredondo, Alberto Moreno, Dario Salvi and Sergio Guillen is elaborating on the work on the user interaction for the example of the heart failure management application concept.

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