

SAPHE

Date: 08/09/2006

Executive Summary

The use of preventative care and effective chronic disease management to reduce dependence on health and social care services is a national priority. Chronic disease will be the leading cause of disability by 2020 (WHO 2002, DH Chronic Disease Mgt, 2004) and two-thirds of patients admitted as medical emergencies have exasperation of chronic disease or have chronic disease (DoH, Improving Chronic Disease Management, 2004). The purpose of SAPHE is to develop and trial a novel architecture for unobtrusive pervasive sensing to link physiological parameters and lifestyle patterns for improved well-being monitoring and early detection of changes in disease. SAPHE is fundamentally different to traditional telecare and vital signs monitoring based on event triggered responses. Instead, it is focussed on the need for a new generation of pervasive healthcare and lifestyle monitoring systems to allow for early detection and prevention of acute events.

SAPHE encompasses innovative technical developments, system integration, NHS PCT trials, and concrete business and deployment strategies. By sensing under normal physiological conditions, combined with intelligent trend analysis, it opens up new opportunities for the UK ICT and healthcare sectors in meeting the challenges of demographic change associated with the aging population. The project will create a new generation of 'turn-key' solutions that will enable health and care providers to support increased independence for vulnerable people outside health and social service institutions in a form that, compared to existing practice, offers cost savings and efficiencies to care providers whilst being far more acceptable to users.

By combining intelligent ambient and wearable sensing, SAPHE will bring about breakthroughs in a number of technological fronts and future pervasive healthcare provision:

- Miniaturised sensing with self-management and configuration
- Local data abstraction and sensor fusion/inferencing with low power sensor and wireless data path
- Processing-on-node technology for context aware sensing
- Automated trust-based decision support and "affective computing" for improved human-computer interfacing
- Intelligent trend analysis and large scale data mining

A 20 user trial will investigate the potential impact of a SAPHE system aimed at reducing movement up the 'care pyramid' of increasing dependence on health and care services. The management and cost of care pathways for local health / social services will also be explored together with the potential benefits to end users (patients and informal carers).

SAPHE Scenario

Bill is a 71 year old male living in Liverpool on his own. His two grown up children, Linda (50) and Liam (48) both live reasonably close by but both work full time and have their own families to keep them busy. They tend to drop in on Bill once a week each. Bill suffers from Dementia and COPD but is strongly independent.

Three months ago Bill had two minor falls. Each fall involved overnight hospitalisation, and led to Linda visiting more and more often as she became very worried about her father's ability to cope with his conditions. Linda took Bill to his check up appointments but he rarely talked to the doctor when he was there and left all the talking to Linda. Linda found this difficult as she didn't know the exact pattern of her dad's symptoms as well as he should himself. The problem was that Bill could not recall his symptoms and behaviours from day to day or at worse from hour to hour and it has already proved impossible for him to maintain a journal as his doctor had first suggested.

Linda believed that Bill was unable to regulate his behaviour; on 'good' days he would overexert himself whereas on 'bad' days he will just sit in front on the TV and will barely eat or drink.

Linda wished there was a way both her and Bill could somehow record or remember his symptoms and how they get worse or better over the day, or even a full week or month before they visit or speak with the doctor again. Even June, Bill's home help, has mentioned to Linda that she is often unable to determine if it is a good day or a bad day for Bill and such information would help her to schedule when best to visit and whether or not to make him something to eat when she arrives. The doctor agreed he would like to build a better picture of Bill's changing symptoms to help him decide how to manage his conditions better and reduce his risk of further falls which would have resulted from his fluctuating behaviour. The doctor referred Bill onto his PCT's SAPHE system which was installed soon after.

The installed SAPHE system non-invasively monitors Bill's activity within his home at all times via small sensors in each room. Bill's breathing and SpO2 are also monitored via discrete wearable sensors and a small unit he wears on his belt during the day and docks on his bedside table at night-time. His home carer assists him with checking the wearable devices each morning and night although, if prompted, Bill can manage them himself now.

For the last two months the technology has provided Bill's doctor with a longitudinal record of Bill's physiology and correlated behaviour with key trends and episodes highlighted. This has allowed the doctor to adjust Bill's medication plan to be more appropriate and he has set the system to issue phone based medication reminders due to Bill's forgetfulness.

Access to summaries of Bill's status and daily activities are also provided to Bill's community matron, Debbie, and to Linda. With more detailed information Debbie is able to better schedule care visits to Bill's needs and can closely monitor his activity levels and events to ensure he remains safe at home and determine early signs of possible health problems. For instance, last month Debbie noticed that Bill was waking up several times in the night and earlier in the morning amounting to only 5 hours of sleep a night. On closer review it was seen that these episodes were accompanied by a drop in Bill's oxygen saturation and a rise in heart rate at rest. Bill was diagnosed with a chest infection (he is more prone to this because of COPD) and what was waking him up was him getting short of breath during the night. The early diagnosis allowed treatment of the infection with oral antibiotics and prevented hospital admission. Information from the SAPHE system is also reviewed as part of the Multi-Disciplinary Team patient reviews that involve Debbie, the GP, and hospital clinicians. The system makes sharing information between the individuals much simpler.

Linda is reassured by the simple daily summaries she receives of her father's status and that she will be alerted if a cause for concern is detected such as a possible fall. She continues to visit Bill regularly but now does so more out of enjoyment than concern. The fluctuations in Bill's well-being are now much reduced and he says he feels happier now than he has felt for some time.

Note: This scenario has been developed from the MATCH scenario 'Electronic Presentation of Chemotherapy Symptom Data'.

Why SAPHE?

Improving the management of chronic disease is a key priority for national health policy. One major objective is to ensure that patients with chronic diseases should be treated in a community setting or supported at home whenever possible, resulting in improved patient well-being, lower demand for healthcare, released healthcare capacity, and allowing more effective use of resources through the use of a patient-centric approach. Existing telecare systems fall short of these demands as they are mainly concerned with remote monitoring of basic activity and limited physiological data, the context of which is usually poorly defined.

SAPHE represents a new generation of pervasive healthcare and lifestyle monitoring paradigms in that it allows for early detection and prevention of adverse events before they become critical or life threatening. This will be achieved through parallel monitoring and correlation of both physical activity (e.g. activities of daily living, sleep patterns, gait etc.) and physiology (e.g. heart rate, weight, blood glucose etc.). For example, in the elderly population, prostatism, degenerative joint disease, bursitis, and gastroesophageal reflux are common causes of frequent awakening episodes and disturbed sleep. Distress from acute symptoms of a psychiatric disorder may also promote disturbed sleep, and certain restless limb movement during sleep may be associated with renal failure and iron deficiency. Research has shown that changes in gait can be associated with early signs of neurological abnormalities linked to several types of non-Alzheimer's dementias. Unstable gait can also be a major factor contributing to falls, some of which can be fatal. For the patient, consequences may include fracture, anxiety and depression, and loss of confidence, all of which can lead to loss of independence, greater disability and an increased burden on health and care systems.

Benefits to Patients

- Truly pervasive, easy to wear and requires minimal user interaction
- Sensing under normal physiological conditions
- Reassurance of wellness for patients and carers
- Early detection of the onset of disease before it is critical or life threatening
- Combined disease and well-being monitoring
- Smart to wear, multi-function, and avoids stigmatising
- Reconfigurability of the devices means constant improvement of the system capability
- Intelligent ambient sensing can ultimately replace existing home security and monitoring devices, and therefore brings significant cost benefit

Benefits to Health and Care Providers

- Early detection means better informed care activities and improved resource management
- Trend analysis and decision support simplifies care workflow management and decreases staff/client ratio
- Pervasive, easy to install and customise with minimal additional work during system deployment
- Sensing under normal physiological conditions ensures improved patient compliance and acceptance
- Reconfigurability for the ease of adapting care/monitoring as the requirement or condition of the patient changes
- Pooled population data provides evidence based care provision and more accurate financial planning

SAPHE Architecture

The SAPHE architecture consists of three main components: ambient sensing, wearable sensing, and inferencing/decision support.

Ambient sensing – provides generic behaviour profiling and activity recognition. It is disease independent and captures information such as activity index, sleeping pattern, room occupancy, and gait and posture changes. SAPHE will use a variety of non-invasive sensors throughout the home to provide continual activity and environmental monitoring of the individual within their dwelling. For example, intelligent motion tracking sensors, smart appliance sensors and utility usage sensors. Ambient sensors require no user interaction and are perpetual, low cost, and reconfigurable.

Wearable sensing – provides patient specific monitoring of key physiological indices as well as contextual information. For asthma/COPD patients, this will provide information about respiration, peak expiratory flow and oxygen saturation. SAPHE will not set out to provide a full-range of wearable sensors for different chronic diseases. Instead, it will concentrate on the development of a common node architecture that can be adopted by OEM sensor suppliers for connecting with specific physiological and biochemical sensors. For initial clinical validation of the project, SAPHE will provide a wearable sensing node that provides a subset of common physiological measurements for the management of chronic heart failure, asthma/COPD, diabetes, dementia, and homecare of the elderly.

Inferencing and decision support – SAPHE will adopt a distributed inferencing paradigm that combines on-node processing and remote long term trend analysis. In terms of decision support, a two tiered configuration will be used. This consists of a home gateway which coordinates the information gathering, local inferencing and decision support from both ambient and wearable sensors. For patients on the move, this role will be taken by a portable device such as a PDA or mobile phone. The gateway devices provide connectivity to remote data servers and existing healthcare ICT architecture where long-term trend analysis can be performed based on individual and pooled population data. Issues concerning data protection, security, and conformance to standards will also be addressed.

