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mPHASiS: Mobile patient healthcare and sensor information system

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ABSTRACT

Pervasive care and chronic disease management to reduce institutionalization is a priority for most western countries. The realization of next generation ubiquitous and pervasive healthcare systems will be a challenging task, as these systems are likely to involve a complex structure. Such systems will consist of various devices, ranging from resource-constrained sensors and actuators to complex multimedia devices, supporting time critical applications. This is further compounded by cultural and socio-economical factors that must be addressed for next generation healthcare systems to be widely diffused and used. In this study, the requirements for a vital sign monitoring solution space is derived and mPHASiS is developed based on these requirements. mPHASiS is an end to end solution not only providing sensor networking and vital sign monitoring but also closing the loop by signaling alert messages to the caregiver and allowing pervasive access to vital signs of a patient using smartphones over a heterogeneous network. A role based access control mechanism is developed to limit access to sensitive data. The end to end delay and delay variations for both vital sign data collection and pervasive access are analyzed. mPHASiS is developed as a complementary solution augmenting functionality of a hospital information system and can be loosely couple with the hospital information system using webservices.

1. Introduction

Advances in wireless sensor networking have opened up new opportunities in healthcare systems. The integration of existing specialized medical technology with pervasive, wireless wearable health monitoring sensors is pushing new boundaries. Pervasive sensor technologies co-exist with the installed infrastructure, augmenting data collection and real-time responses. These sensors can improve the quality of healthcare for the world's increasingly aging population. According to US census bureau, one-third or more of the 78 million baby boomers and 34 million of their parents may be at risk for development of devastating chronic diseases (U.S. Census Bureau). These diseases include heart disease and stroke, arthritis, diabetes, epilepsy, sleep apnea, asthma and allergies. Experts believe that presymptomatic testing could save millions of lives in the coming decades.

According to Center for Disease Control and Prevention's (CDC) 'The World Health Report' (US Department of Health and Human Services, 2006), heart disease and stroke are the first and third leading causes of death for both men and women in US, accounting for nearly 40% of all deaths. Over 927,000 Americans die of cardiovascular disease each year, equivalent to 1 death every 34 seconds. Although these preventable conditions are more common among people aged 65 years or older, sudden deaths from heart disease among people aged 15–34 have increased. In addition, more than 70 million Americans live with a cardiovascular disease. Coronary heart disease is a leading cause of premature, permanent disability in the US workforce. Stroke alone accounts for disability among more than 1 million Americans. Over 6 million hospitalizations each year are due to cardiovascular diseases. The economic impact of cardiovascular disease on the US health care system continues to grow as the population ages and is projected to be $394 billion, including health care expenditures and lost productivity. This impact can be lessened and an increased human lifespan can be achieved via pervasive monitoring of health indicators to detect diseases early. Not only does it help to reduce the effect of chronic illnesses, it also may potentially save lives.

Traditional personal medical monitoring systems such as Holter monitors can collect data for up to 24 hours (American Heart Association). However their usage has been limited due to its numerous wires and adhesive electrodes, making it cumbersome and unnatural for the user to wear continuously and can influence the wearer's natural behavior and skew the results. To address these drawbacks, several advanced ECG monitoring systems are emerging which offer off-line continuous data collection capabilities and can also signal a warning in real-time (Oliver and Flores-Mangas, 2005). Recent research has focused on the development of body sensor networks (BSN) and pervasive monitoring systems. For example, CardioNet provides a remote heart monitoring solution where ECG signals are transmitted to the

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