Chapter 24
mVITAL:
A Standards Compliant Vital Sign Monitor

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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 are derived and based on these requirements a standards compliant medical device networking solution is presented. mVITAL is an end-to-end solution based on IEEE-11073 framework. IEEE-11073 defines a family of standards and nomenclature for device communication protocol, data format and logical interface between monitoring station and standard compliant medical devices. mVITAL is not only providing medical sensor networking and vital sign monitoring but also closes 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 the access to secure data. The end-to-end delay and the variations in delay for both the sensor data collection and the pervasive access are analyzed. mVITAL is developed as a complementary solution augmenting functionality of a hospital information system and can be loosely coupled with the hospital information system using web services.

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 are important to the world's increasingly aging population. According to US census Bureau (2000), 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. These diseases include heart diseases & stroke, arthritis, diabetes, epilepsy, sleep apnea, asthma and allergies. Experts believe that pressymptomatic testing could save millions of lives in the coming decades.

According to Centers for Disease Control and Prevention (2006) "The World Health Report", 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 has 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 U.S. workforce. Stroke alone accounts for disability among more than 1 million Americans. Over 6 million hospitalizations each year are due to cardiovascular disease. The economic impact of cardiovascular disease on the U.S. health care system continues to grow as the population ages and is projected to be $394 billion, including health care expenditures and lost productivity. It has been suggested that 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 reduce the effect of chronic illnesses, it also may potentially save lives.

Increasing costs in medical treatment of patients and high costs involved with housing patients in a hospital have given rise to an imminent need for finding new ways for a patient monitoring system. Some chronic illnesses require the physician to monitor the patients for longer periods of time, albeit keeping the patients in the hospital may not be absolutely necessary. Time delays in the delivery of medical alerts to the physician and securing physician's response may be catastrophic. Physicians also face a tough task with their rotating shifts and night time visits in critical situations due to lack of real time vital sign data feeds as well as lack of on-site expertise to interpret the data with patient's pertinent medical background.

There is also a concern about communication standards different vendors use for the medical devices. Most medical device vendors provide RS-232 digital serial or analog outputs with custom data packing formats. Even popular standards like RS-232 with multiple physical layer variations, multiple pin connectors and signaling protocols can create problems. The problems with non-compatible vendor standards are discussed in (Fuchs, 2008). The IEEE 11073 standard family addresses these issues and defines a standardized nomenclature of different components of a medical device monitoring system. IEEE 11073 characterizes the protocols to be used for communication and provides a standardized medical device and the monitoring interface. Though IEEE 11073 is still under specification phase, there is definitely a growing interest from the medical device vendors to make a move towards standardization efforts for application, transport, network and physical layers and eventually making them analogous to International Standards Organization's (ISO) Open Systems Interconnections (OSI) specification.

Studies revealed that, unobtrusive, wearable sensors will allow vast amount of data to be col-

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