



Challenges in Wireless Sensor Networks Used for Healthcare

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ABSTRACT: Becoming mature enough to be used for improving the quality of life, wireless sensor network technologies are considered as one of the key research areas in computer science and healthcare application industries. The pervasive healthcare systems provide rich contextual information and alerting mechanisms against odd conditions with continuous monitoring. This minimizes the need for caregivers and helps the chronically ill and elderly to survive an independent life, besides provides quality care for the babies and little children whose both parents have to work. Although having significant benefits, the area has still major challenges which are investigated in this paper. We provide several state of the art examples together with the design considerations like unobtrusiveness, scalability, energy efficiency, security and also provide a comprehensive analysis of the benefits and challenges of these systems.

KEYWORDS: wireless sensor network, healthcare, monitoring, challenges, scalability, energy, efficiency

I. INTRODUCTION

Wireless sensor network technologies have the potential to change the way of living with many applications in entertainment, travel, retail, industry, medicine, care of the dependent people, and emergency management and many other areas. Wireless sensors and sensor networks, pervasive computing, and artificial intelligence research together have built the interdisciplinary concept of ambient intelligence (AmI) in order to overcome the challenges we face in everyday life. One of the major challenges of the world for the last decades has been the continuous elderly population increase in the developed countries. Population Reference Bureau forecasts that in the next 20 years, the 65-and-over population in the developed countries will be nearly 20% of the overall population.¹ Hence the need of delivering quality care to a rapidly growing population of elderly while reducing the healthcare costs is an important issue. One promising application in that area is the integration of sensing and consumer electronics technologies which would allow people to be constantly monitored.² In-home pervasive networks may assist residents and their caregivers by providing continuous medical monitoring, memory enhancement, control of home appliances, medical data access, and emergency communication. Constant monitoring will increase early detection of emergency conditions and diseases for at risk patients and also provide wide range of healthcare services³ for people with various degrees of cognitive and physical disabilities. Not only the elderly and chronically ill but also the families in which both parents have to work will derive benefit from these systems for delivering high-quality care services for their babies and little children.⁴

Researchers in computer, networking, and medical fields are working together in order to make the broad vision of smart healthcare possible. The importance of integrating large-scale wireless telecommunication technologies such as 3G, Wi-Fi Mesh, and WiMAX, with telemedicine has already been addressed by some researchers. Further improvements will be achieved by the coexistence of small-scale personal area technologies like radio frequency identification (RFID), Bluetooth, ZigBee, and wireless sensor networks, together with large-scale wireless networks to provide context-aware applications⁵. Besides providing pervasiveness with existing and relatively more mature wireless network technologies, the development of unobtrusive small sensor devices enabling not only accurate information but also reliable data delivery is of great importance. Moreover, the glue combining all these technologies is the application, which is the coordinator between the caregivers and the caretakers and between the sensor devices and all of the actors in the overall system cycle. Since the application is the core of the high-quality healthcare service concept, the need for intelligent, context-aware healthcare applications will be increased.⁶

Given the importance of the subject, there are already several applications and prototypes on the subject. For example, some of them are devoted to continuous monitoring for cognitive disorders like Alzheimer's, Parkinson's or similar cognitive diseases. Some focus on fall detection, posture detection and location tracking and others make use of biological and environmental sensors to identify patients' health status. There is also significant research effort in developing tiny wireless sensor devices, preferably integrated into fabric or other substances and be implanted in human body.⁷



There are other survey studies in the literature. However, these studies have either only smart home perspective or limited information about the design issues and challenges. In this survey, we evaluate the state of the art research activities and present issues that need to be addressed to enhance the quality of life for the elderly, children and chronically ill people. We provide survey of the recent research on future intelligent monitoring applications not only from a smart home perspective but rather from a more healthcare related perspective. We also discuss benefits that will be achieved and challenges that will be faced while designing the future healthcare applications.⁸

II. DISCUSSION

In the 21st century, the healthcare industry has seen the drastic improvements due to the involvement of wireless medical sensor networks (WMSNs) in healthcare applications. A few decades ago WSNs were a topic of science/movie fiction for healthcare industries, and now they have become a reality and provide much quality-of-care.⁹ As the world's aging population is increasing at an unprecedented rate in the developed and developing countries. According to the "An Aging World: 2008" report in 2008 the number of aging people worldwide (i.e., 65 years and older) was estimated at 506 million, and by 2040, that number will touch 1.3 billion. Thus, in just over three decades, the percentage of older age people will increase two times from 7% to 14% of the total world population.¹⁰ Although the aging population signifies, a human success story of increased longevity, the steady, sustained growth of the older population also poses health challenges. As more and more people will be entering an elder age, the risk of developing certain chronic and debilitating diseases is significantly higher. For example, Alzheimer disease symptoms typically first appear after age 60, Heart disease and stroke rates rise after age 65, diabetes, like those of many other conditions (e.g., blood pressure, blood glucose levels etc.).¹¹ Further, if aged populations prefer to live alone they do however require long-term monitoring for better independent life.¹² Thus the aging population desperately demands independent life and good quality-of-care without disturbing their comfort, while reducing their care costs. In this context, wireless sensor technology could provide highly useful tools for elderly people health monitoring and patients who need continuous monitoring.¹³ Consequently healthcare using wireless sensor networks constitutes an exciting and growing field for scientific investigation. In fact the future of modern healthcare in an aging world will need ubiquitous monitoring of health with least actual interaction of doctor and patients. Recently, a term wireless medical sensor network (WMSN) has coined to bring many researchers together from interdisciplinary areas (bioengineering, electronics, computer, medicine)¹⁴

III. RESULTS

The development of a wireless healthcare application offers many novel challenges, such as, reliable data transmission, node mobility support and fast event detection, timely delivery of data, power management, node computation and middleware. Further however, deploying new technologies in healthcare applications without considering security often makes patient privacy vulnerable. For instance, the patient's physiological vital signals are very sensitive (i.e., if a patient has some embarrassing disease),¹⁵ so any leakage of individual disease data could make him/her embarrassed. In fact sometimes revealing disease information can result in a person losing his/her job, or make it impossible for him/her to obtain insurance protection. Further, wireless medical sensor networks cover a broad range of healthcare applications, such as physiological data monitoring, and activity monitoring in health-clubs, location tracking for athlete, etc.¹⁶ Consequently, WMSNs share individual data with physicians (in a doctor-patient relationship), insurance companies (as insurance protection), and health-coaches (as sports team trainers) or with family (as relatives' support). Therefore unauthorized collection and use of patient data by potential adversaries (such as insurance agents, for political reasons, rival coaches, personal enemies etc.) can cause life-threatening risks to the patient, or make the patient's private matters publically available¹⁷. For example, in a simple scenario, a patient's body sensors transmit his/her body data to a nurse/caregiver; it may happen that an attacker is also eavesdropping the patient data while the data is transmitting, and consequently the patient's privacy is breached.¹⁸ Later that attacker can post the patient data on a social site (FaceBook or Twitter, etc.), and thus pose risks to the patient's privacy. Indeed wireless healthcare can offer many advantages to patient monitoring, but the physiological data of an individual are highly vulnerable, so security and privacy become some of the big concerns for healthcare applications, especially when it comes to adopting wireless technology. More importantly, a healthcare provider is subjected to strict civil and criminal penalties (i.e., either fine or imprisonment) if HIPAA rules are not followed properly. Thus a patient security and privacy is the central concern in healthcare applications¹⁹.

IV. CONCLUSIONS

Problems on healthcare delivery have become the current concern in most studies in the academe and industries. These studies have been conducted by using evolving technical solutions. These solutions are driven by technological advancements both in medical sensors and low-power networked systems.²⁰ Wireless Sensor Networks (WSNs)



prompted the emergence of most healthcare systems in recent years. This work proposes a system architecture for a remote healthcare monitoring system using pulse sensor and temperature sensor to measure the physiological parameters including Heart Pulse (HP) and temperature of patients.²¹ The system is evaluated using several persons with different ages, gender, and situations. The conducted technique is achieved respecting to the cost of service, signal quality, and quality of service. Finally, the current system is effective given that all reported results are standard values.²²

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