A Ubiquitous Mobile Telemedicine System for Elderly using RFID

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Abstract. The impact of Radio Frequency Identification (RFID) technology as a ubiquitous component in the information age is expanding with new and innovative applications in retail, government, manufacturing and healthcare. In addition to that, the percentage of the elderly population grew rapidly in recent years, so the tremendous life and health care needs became an issue of vital importance in an aging society. In a health care context, the use of RFID technology can be employed for cutting down health care costs. The main goal of the presented research in this paper is to develop a cost-effective user-friendly telemedicine system utilizing RFID technology to serve the elderly and disabled people in the community. The research also aims at establishing a continuous communication link between the elderly and caregivers and allows physicians to offer help when needed.

1 Introduction

Nowadays, a third or more of the 78 million baby boomers and 34 million of their parents may be at risk for the development of devastating diseases including cardiovascular disease, stroke and cancer. Chronic diseases are becoming the world's leading causes of death and disability, and will account for almost three-forth of all deaths by 2020. Each year, number of deaths caused by cardiovascular diseases and hypertension is estimated to be 16.7 million and 7.1 million, respectively [1]. The implications of these wearable health monitoring technologies are paramount, since they could: bring healthcare to remote locations and developing countries, and transform health care by providing doctors with multi-sourced real-time physiological data. [2]. With the advent of advanced telecommunication technology, the current trend in long-term care nowadays is a shift of the delivery system away from institutional care towards home and community-based care. In addition to that, mobile/sensor technology is expected to provide real-time information about vital signs and other physiological indicators of one’s health. Such monitoring systems are expected to find greater use in such applications as hospitals, home health monitoring, and health research studies. The application of mobile telemedicine can be facilitated by the use of the mobile technology such as Radio Frequency Identification (RFID) [3]. In a mobile telemedicine, RFID systems are also beginning to be used more widely. For instance, in 2003 the Alexandra Hospital in Singapore used an RFID tracking system to track a severe acute respiratory syndrome (SARS) outbreak. In

Raad M. (2009).
A Ubiquitous Mobile Telemedicine System for Elderly using RFID.
In *Proceedings of the 3rd International Workshop on RFID Technology - Concepts, Applications, Challenges* , pages 109-116
DOI: 10.5220/0002199201090116

2003, Intel established the Centre for Aging Services Technologies (CAST). In 2004, CAST demonstrated a monitoring system that keeps track of medicine bottles, teacups used regularly at home by affixing RFID tags on the items and by attaching an RFID reader to the back of an elderly hand [4].

The combination of RFID infrastructure and wearable bio-sensors provide continuous tracking and monitoring of physiological condition of the elderly people [5]. Intel's Caregiver's Assistant and Georgia Tech's Memory Mirror use RFID tags to monitor the activities of the elderly at home and help caregivers to improve the quality of healthcare. Until now, health care services could only be provided within the physical space of a hospital. Ubiquitous computing environment with the help of RFID will extend the reach of medical services to common environments [6]. Hence, in response to this need we are proposing in this paper a working prototype of a telemedicine system for delivering healthcare at home as well as in hospital utilizing RFID technology. The proposed system has the benefit of enhancing the quality health care delivery for elderly people with chronic diseases.

2 RFID Primer

An RFID device is a small microchip designed for wireless data transmission. In an RFID system, a RFID tag transmits data over the air in response to interrogation by an RFID reader. The low-cost RFID tag is able to read or write information of an entity without contact directly, while possessing a fast recognition speed. Each tag contains a unique identifier that makes it different from every other tag in a specific set. The antenna is used to communicate with the reader [7] , [8], [9], [10], [11].

3 RFID in Telemedicine

In this section, a possible application scenario for telemedicine for elderly is proposed, assuming an elderly to be in hospital or at home. The elderly person might be handicapped in various ways, as senses and capabilities to remember are not good. Also his relatives, who might be spread all over the world, would like to make sure he is alright and perhaps keep an eye on him 24/7. The elderly is not able to see a physician anytime he needs, because he is unable to make his way to the clinic or hospital. Therefore, a solution must be developed to allow an elderly to talk to his physician in a user-friendly manner. The physician must have a remote-view of the vital signs that physicians look at like Electro Cardiogram (ECG), oxygen saturation, blood pressure, heart rate, etc... In case of emergency, a reliable emergency system must call a physician and ambulance for help. RFID is one of the emerging technologies offering a solution, which can facilitate automating and streamlining safe and accurate elderly identification, tracking, and processing important health related information in health care sector such as hospitals [3]. The system has the capability also to call for a ROBOT assistant to guide the elderly inside the hospital. Since health is a critical issue, the elderly profile is stored in our case on an RFID tag/bracelet which is identified by a unique identification number (UIN). RFID

technology provides a method to transmit and receive data from an elderly to health service provider/medical professionals without human intervention (i.e., wireless communication). The importance of the proposed RFID solution lies in the fact that the RFID bracelet carrying the elderly profile & clinical data stays with him wherever he goes, particularly while at home, thus opening avenues for utilizing the RFID bracelet as a telemedicine tool after hospitalization. The RFID tag/bracelet can be used in the future to monitor and control medication dispensing for elderly both when they are in hospital and after hospitalization when they are residing at their own home.

3.1 Objectives

For an elderly or handicapped person, the main goal is to overcome the limitations in life and to provide successful aging at home or while at hospital. We can list a set of objectives for a ubiquitous RFID Telemedicine system for elderly and disabled. These goals constitute the main building blocks for the research. The main objectives of the proposed research are the following:

- The first objective is improve elderly care in hospitals as well as outside hospitals, helping using robotic systems in case of emergencies, track treatments and outcomes and provide accurate track of the elderly treatment utilizing RFID technology.
- The second objective is to capture the elderly vital signs continuously and to allow the physician or caregiver to interact with the elderly remotely and to keep the physician up to date, and initiate emergency call and provide video/audio communication wherever he is.

3.2 The Proposed System Architecture

In the following section, a system architecture based on the given objectives is developed. Figure 1 shows an overview of the general layout of the elderly monitoring proposed system using an IP digital camera and the web, in addition to a GSM modem for sending emergency messages or calls to the physician as well as the ambulance. The data base is used to store the information related to the health status of the elderly to be analyzed by a physician or care giver.

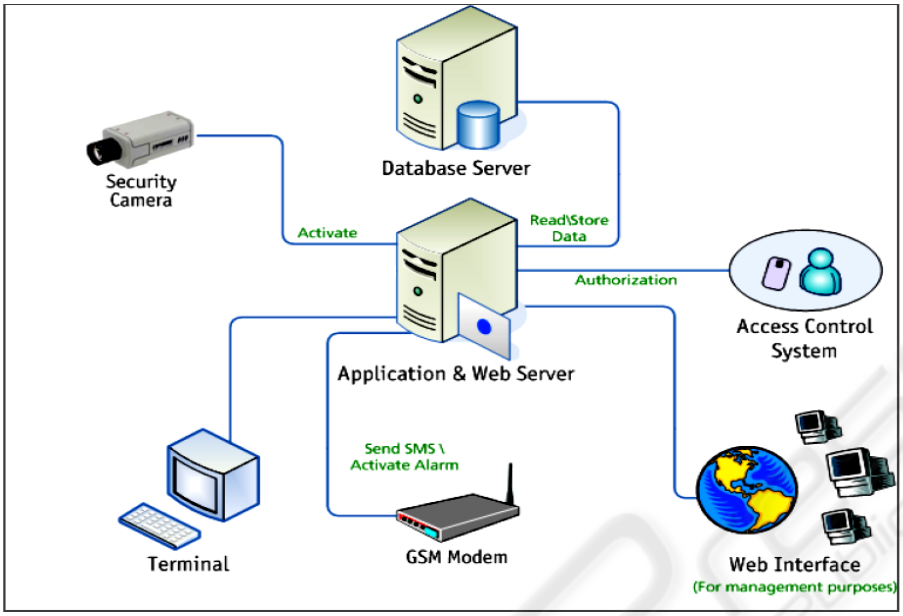

Fig. 1. An overall layout of the elderly monitoring system.

The focus in this paper is on a hospital scenario for telemedicine, which has also the capability to monitor the elderly at home. To make this possible, the bio sensors capturing the vital signs are programmed to communicate with a centralized station using Ad hoc network or even wireless infrastructure LAN. The medical wearable sensors capture the vital signs of the elderly and send these vital signs upon request to the physician. Two of these sensors included in the proposed design are the pulse oximeter sensor and the blood pressure sensor. These sensors are implanted on a wheel chair, dedicated to help the elderly to move around while at home, particularly after hospitalization, and be in direct contact with his caregivers or physician, to keep them informed in case of any complications which might occur to the elderly health. See figure2 for the hardware layout of the vital sign sensors. The sensors are connected to a lab top or a PDA on the wheel chair, which sends this data through WIFI to a server for further analysis. The proposed telemedicine system has been successfully tested for sending high and low blood pressure alarms remotely. The blood pressure sensor is off the shelf wearable sensor with USB type interface. The proposed telemedicine solution helps improving the activity of daily living (ADL) of the elderly. The system was tested in the lab for sending blood pressure and pulse rate values to a data base server as well as sending high and low pressure alarms through SMS (short message service). The purpose of the RFID wearable bracelet is to automatically log all unusual symptoms collected by the bio sensors from the elderly to facilitate the diagnosis process by the physician, especially in the case of elderly people suffering from Alzheimer.

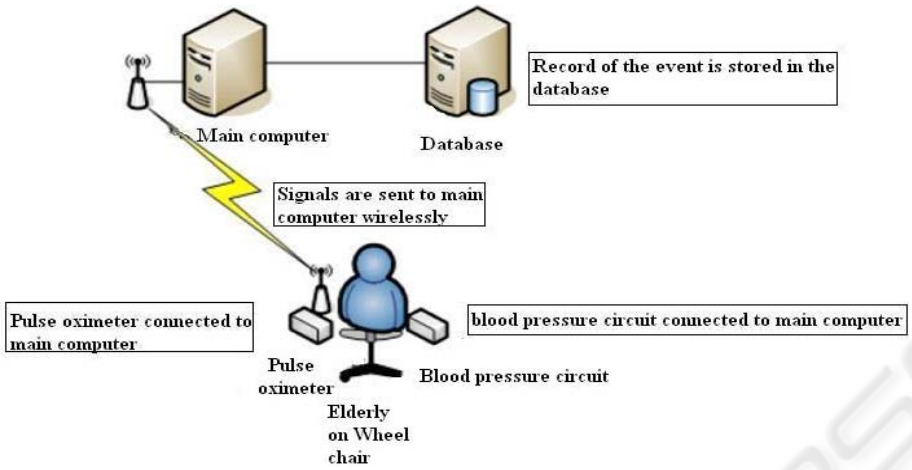

Fig. 2. Overall layout of the vital sign sensors.

4 The RFID Hospital Scenario

4.1 System Architectural Solution

In the context of the hospital, every elderly with chronic disease or under hospital treatment is given an RFID bracelet upon registration. The bracelet has an RFID tag attached to it, which contains clinical data about the elderly, in addition to information pertaining to appointments with his doctor and his prescriptions. Once the elderly arrives to hospital, the tag attached to the bracelet is energised by an RFID reader (interrogator) fixed at the hospital entrance, and the RFID reader detects the tag and passes its unique serial number to a server data base to decide upon the desired action. The hospital server sends a request for a robot assistant, which has a built in WIFI enabled TINI microcontroller to lead the elderly to the proper treatment area using WIFI network. This is particularly vital for elderly people who suffer from Alzheimer for instance and tend to loose their way easily. In the case of emergency, priority is given to those who have to be treated under emergency condition. The proposed ubiquitous hospital solution also includes provision for including an option where could be provided with bio wearable sensors while in hospital, in addition to an emergency button for calling for help. This is possible utilizing the TINI microcontroller with a web server on board, supported with WIFI interface to add mobility. This gives full access for doctors, nurses as well as staff to elderly while in hospital, thus removing overhead from staff and nurses, where nurses for can spend more time with other , thus improving productivity. See figures 3 & 4 for the details of the RFID hospital emergency solution.

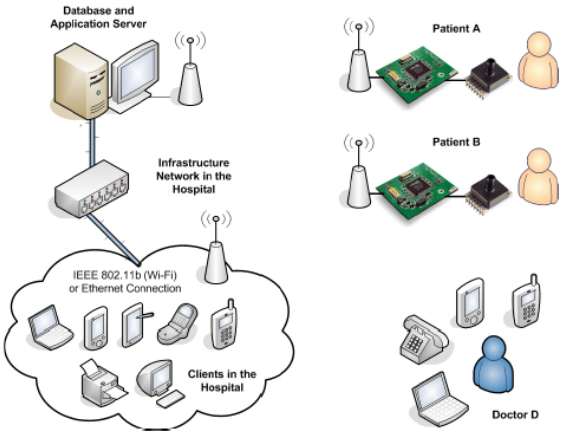

Fig. 3. Wearable biosensor for and communication to servers.

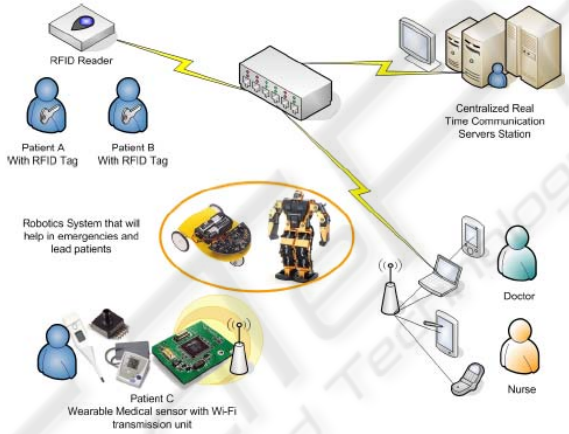

Fig. 4. The full layout of the mobile RFID based emergency system inside the hospital.

4.2 Design Tradeoffs and Performance Evaluation

There are a number of design tradeoffs in choosing the most appropriate RFID tag for the particular application. Although the UHF tags have longer range and faster data rates than the low & high frequency tags, they do not perform well near metal and water as seen in table1. The high frequency tag has a longer range and is cheaper than the low frequency tag. The HF RFID tags are particularly suitable to be used in the form of a wearable bracelet since it penetrates water very well. A working prototype of the ubiquitous RFID telemedicine solution for the hospital scenario has been implemented and tested using Skytel M1 HF reader and 13.56 MHz passive MIFARE tags, utilizing the ISO14443 contact less protocol. The RFID tag used is in a wearable bracelet form. The HF RFID tags are also considered the most common type of RFID tags complying with an international ISO standard, allowing us to ‘plug and

play' between multiple tag and reader vendors. Table 2 shows the differences before and after RFID introduction.

Table 1. Summary of RFID tag characteristics for low, high and ultra-high frequencies.

Frequency Range	LF 125 KHz or 134 KHz	HF 13.56 MHz	UHF 868-915 MHz
Approx. Tag Cost	> $1	$0.5 - $1	$0.10
Approx. Reader Cost	$300	$200	$1500
Max Read Range (Passive)	1ft or less	3ft	16ft
Data Rate	Slower <----------> Faster		
Ability to Read Near Metal and Liquids	Better <----------> Worse		
Passive Tag Size	Larger <----------> Smaller		

Table 2. Proposed advantages for RFID.

	(before) RFID	(after) RFID
Prescription	Manual	paperless
Hospitalization	Manual retrieving (paper file)	Paperless (automated by RFID)
Healthcare advice	Limited time to do	More time to give advice

5 Discussion and Conclusions

The use of mobile telemedicine along with RFID will soon provide higher-quality service and increased efficiency to the practice of medicine. Emergency and critical response professionals can be given immediate access to a wealth of vital information, particularly for the elderly and disabled. It also becomes possible to observe and deliver care to while living in their homes, instead of spending months or even years in hospital. The use of RFID as a ubiquitous component in telemedicine opens avenues for research in healthcare. With the development of new products from telemedicine, there is a growing need to develop standards for the field. Standards will improve reliability and allow the interoperability of the various different services being created. The proposed design represents a good approach to research in mobile telemedicine for elderly using RFID, keeping in mind that many things have been

generalized to a certain extent and the analysis of the vital sign data captured from the medical sensors is still an on going research. Our future efforts will primarily focus on integrating RFID tags with medical bio sensors, which will facilitate establishing a ubiquitous monitor environment to help caregivers to serve the elderly while at home. Certain crucial issues still have to be resolved regarding the user-friendly ness of the telemedicine system and how does the elderly interact with all of this complex technology, in addition to measures which have to be taken to ensure the privacy of the web enabled solution which physicians use to view the health status of the elderly since the web is vulnerable to hackers.

Acknowledgements

The author would like to acknowledge the support of King Fahd University Petroleum & Minerals for its support.

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