WIRELESS VITAL SIGNS MONITORING SYSTEM FOR UBIQUITOUS ECG HEALTHCARE

Abstract:* ECG data is a commonly used vital sign in clinical and trauma care. The ECG data is displayed on a graphical user interface (GUI) by transferring it to a PDA or a terminal PC. The results showed how the relationship between the bit-error-rate (BER) and signal-to-noise ratio (SNR) was affected when varying the distance between sensor node and base-station, through the deployment of the number of sensor nodes in a network and through data transmission using different time intervals. A performance evaluation of the reliability of IEEE 802.15.4 low-rate wireless ubiquitous health monitoring is presented. The results showed how the relationship between the bit-error-rate (BER) and signal-to-noise ratio (SNR) was affected when varying the distance between sensor node and base-station, through the deployment of the number of sensor nodes in a network and through data transmission using different time intervals(Running, Walking, Resting).

***Keywords:* BER, ECG, IEEE 802.15.4, acceleration signal, personal area networks, reliability analysis, vital signs monitoring**

1. Introduction

An increasingly aging population has raised the concern of many countries about its impact on health care systems. This has led to an urgent need for devising cheaper and smarter ways to provide health care for suffers of age related disease. Recent advances in sensor, communication and information technologies have enabled the development of novel vital signs monitoring systems by which various vital health parameters can be measured, like electrocardiogram (ECG), body temperature, heart rate, blood pressure and oxygen saturation. In particular, wireless healthcare related applications using wireless sensor networks may assist residents and caregivers by providing non-invasive and invasive continuous health monitoring with a minimum interaction of doctors and patients. However, there are some significant disparities, such as node lifetime, packet recovery and medical data collection between existing wireless sensor networks and those required for healthcare. In addition to the basic requirements of being wireless, a future healthcare system based on wireless sensor networks must have support for ad-hoc networks, the mobility of patients or elderly persons, wide ranges of data rates and a high degree of reliability. Also, these systems need to be miniature in size, and should be easily wearable, thus causing the least inconvenience to the patients. The design of a sensor network is application-specific, and different applications have different reliability requirements. Reliable data communication is an important factor for the dependability and quality-of-service (QoS) in several applications of wireless sensor networks. In particular, this is the case for critical care applications of hospitals that allow the continuous monitoring of a patient's vital signs. We must consider the reliability of those sensors, the sampling rate, the number of nodes in the same network and data packet sizes, as well as the reliability of the medical devices themselves. This is closely related to the performance of the system in medical applications.

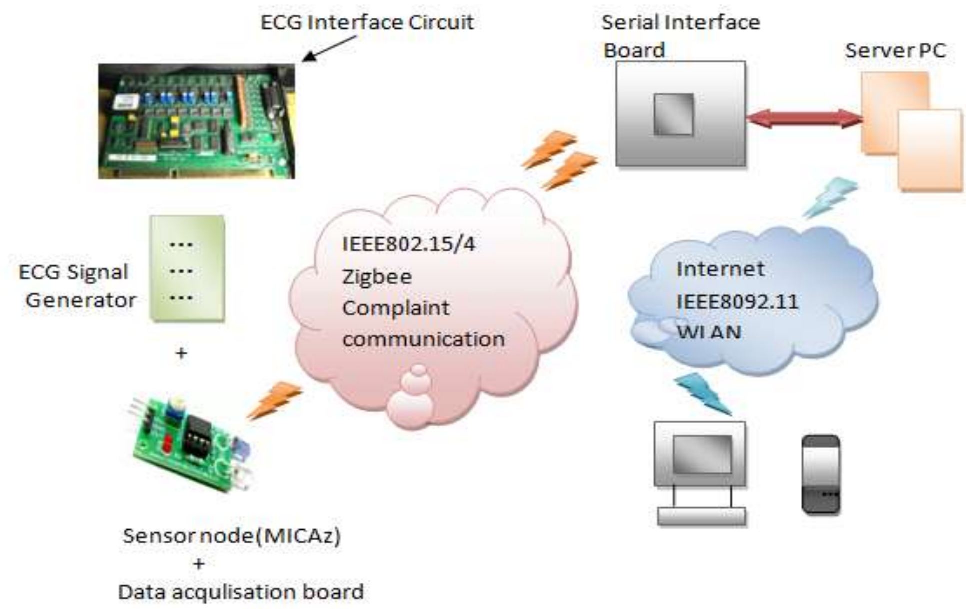

Figure 1: Hardware Configuration of WSN

Figure 1 shows the system architecture of the wireless sensor network platform discussed in this thesis, consisting of four major parts: sensor node, data acquisition board, ECG interface circuit and base-station. As a sensor node, this study used the commercially available MICAz. The MICAz has a Chipcon CC2420 radio chip set operating in the IEEE 802.15.4 standard, an Atmega 128L microprocessor with a data throughput of 250 kbps. The data acquisition board has a maximum of 11 input channels, each with its own 12-bit analog to digital converter (ADC).

2. Literature Survey

Author name	Method	Advantages
Yew-Kiat Cheong, Xiao-Wei Ng, and Wan-Young Chung	The interior health monitoring system like nursing home, pharmacy, and hospital has frequently associated with the mobility, feasibility and high speed features of RF technology to provide the information such as biomedical gestures and patient details	But subsequently, the domination of RF technique in health care is limited due to the emission of RF radiation that would affect the health of the patients. In addition, the interruption of electro-magnetic interferences (EMI) will be menace the quality of medical monitoring as the correctness and competence of the data transmission is made critical for the medical staff to provide Consequent measurement.
Yee Yong Tan, Sang-Joong Jung, and Wan-Young Chung	RF wireless technologies are further emphasized through the banning of RF devices such as mobile phone in the emergency room, intensive care unit (ICU) and similar places.	This limitation can be besieged by the advanced optical wireless communication technologies, by transmitting binary gesture via optical signal through a technique is known as visible light communication or as VLC technology with the light in the visible ranges from 380 to 780 nm
T. Komine and M. Nakagawa	The rapid development in the light emitting diode industry due to its well-known characteristics and inexpensiveness is mainly encourages towards the consistency and acts as the replacement for the RF wireless technology.	The main advantage of LED is that, it can be used for both illumination and communication, further, it poses long life time over traditional incandescent by having more than 50,000 hours, low power consumption, high energy efficiency, fast switching, less heat and less environmental hazards.
H. Elgala, R. Mesleh, and H. Haas	LED is used for both illumination and communication, further, it poses long life time over traditional incandescent by having more than 50,000 hours, low power consumption, high energy efficiency, fast switching, less heat and less environmental hazards.	The tradition of VLC ensures the protection to the patients from RF radiation hazards. Apart from this, the VLC offers a large amount of unlicensed and unregulated bandwidth. It paves a path to the wide-range of ECG signal and the simultaneous patient data transmission using single data packet.
S. S. Ahmad, S. Camtepe, and D. Jayalath,	Healthcare service provider access to the resource to monitor the state of object in any time of day and night. Using these technologies and medical application help to reducing the cost of medical application and also the healthcare service provider able to monitor the objects remotely instead of face to face	WBANs may interact with plenty of wireless technologies such Rube, ZigBee, type of Bluetooth and so on. Regarding to this, this technology help to people to freely move within different environment while healthcare service provider need to access to their health record to monitor the remotely
A. Ehyaie, M. Hashemi, and P. Khadivi,	This opportunity brings some new challenges regarding the nature of WBAN and wireless technologies such as active and passive attack.	It is important to focuses more on the interaction of WBAN with existing technology such as Wireless Sensor Network, which can help to identify the security requirement in medical environment. This can be archive by investigate the existing study in WBANs
S. Movassaghi, M. Abolhasan, J. Lipman, D. Smith, and A. Jamalipour	Sensitive data collected from body sensors and these data aggregate with personal devices such as smartphones.	Then proceed data will be forward into medical server in cloud and so on. Regarding to this, the communication between and within WBANs can be categories in three section, firstly, the communication between sensors called intra communication, Secondly the communication between sensors and personal devices called inter communication.
B. Gyselinckx, C. Van Hoof, J. Ryckaert, R. F. Yazicioglu, P. Fiorini, and V. Leonov	Wireless communication in WBANs provide a platform to how data transmit from sensor to medical server, but wireless techniques are also important that must be consider before deploy networks.	There are a plenty of wireless techniques such as IEEE 802.15.X where researcher used in their model, but IEEE 802.15.6 is the best wireless technique that meet the primary requirement of WBANs.

K. M. Pouryazdanpanah, M. Anjomshoa, S. A. Salehi, A. Afroozeh, and G. M. Moshfegh,	The energy consumption must be considered in 3 ways in WBAN. Firstly, energy consumption related to type of sensor using in WBANs. Secondly, energy consumption related to type of communications between and within WBANs in same and different domain.	Eenergy consumption related to proceeding. There are several researcher focusing on type of sensors to reduce the energy consumption.
S. A. Gopalan and J.-T. Park,	Reliability, energy consumption, data rate, latency and physical layer security is some of main characteristics of IEEE 802.15.6 where highlight.	To provide strong security mechanisms between sensors nodes in BANs in better to use the characteristics physical layer security such as wireless channel.

3. Vital Signs Montioring System

Health parameters obtained from the sensor nodes attached on the body of a patient can be monitored by a PC or a PDA terminal using standard TCP/IP or IEEE 802.11 connections. Integrated to the BSN node there are several wireless biological sensors, including ECG, SpO2, and accelerometers, as well as temperature and skin conductance sensors, used to monitor the patient's vital signs and context information. The base-station is a stand-alone unit, capable of 22 receiving data from the wireless sensor node using an RF receiver, as well as storing and transferring the data to a mobile unit using TCP/IP or IEEE 802.11. Monitoring terminals are utilized to allow clinicians to analyze patient data using such portable handheld devices as laptops, PDAs or cellular phones. In addition to real-time sensor information, historical data can also be retrieved and played back to assist the diagnosis.

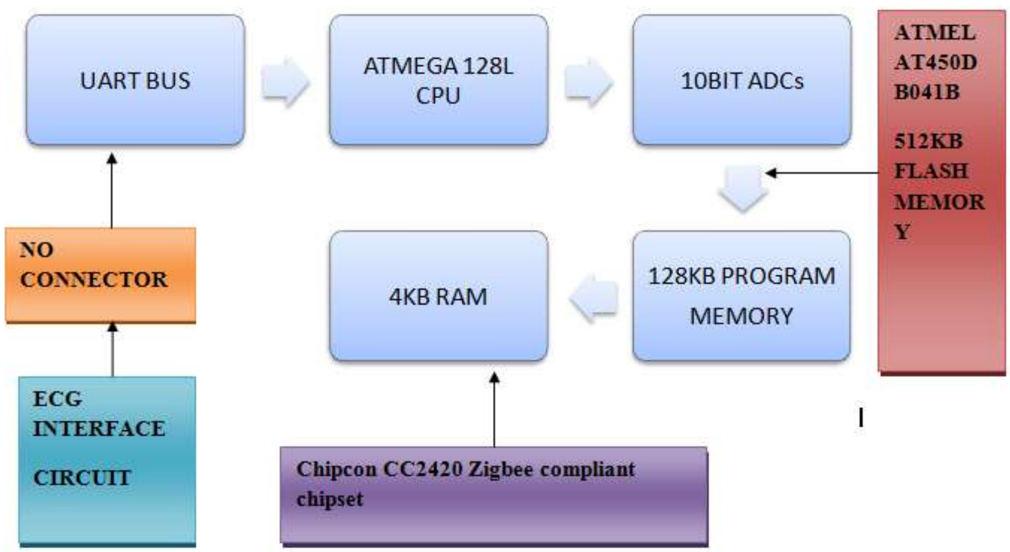

Figure 2: Block diagram of a MICAz sensor node

Figure 2 presents an inside block diagram of a MICAz node consisting of five major modules: a micro-controller with internal flash program memory, Zigbee compliant chipsets (CC2420, Chipcon Ltd., Norway), 512 KB of external serial flash memory, an ECG interface circuit and an I/O connector, functioning as the input port of the sensor's interface circuit.

4. USN Platform

The USN platform features an ultra low power Texas Instruments MSP430 micro-controller] with 10KB RAM, 48KB flash memory and 12-bit A/D converter. It supports several low power operating modes and consumes as low as 5.1uA in sleep mode and 1.8mA in active mode. The CC2420 wireless transceiver is IEEE 802.15.4 Zigbee compliant and has programmable output power, a maximum data rate of 250 kbps and hardware that provides PHY and some MAC layer functions. The CC2420 is controlled by the MSP430F1611 through a SPI port and a series of digital I/O lines. The M25P80 is an 8 MB serial flash memory with a write protection mechanism, accessible from a SPI bus. To minimize the size of the USN platform, the USB programming board was made as a separate module which is needed only when nodes are connected to the PC either for application download or when the node acts as a base-station.

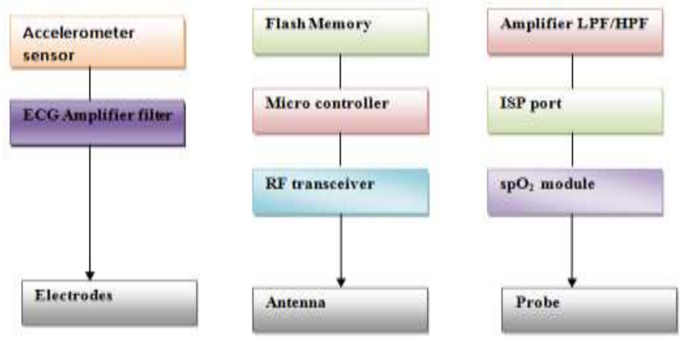

Figure 3: USN Platform

Figure 3 shows a block diagram of the USN platform developed by our laboratory. Recent research has focused on the development of wireless sensor networks and pervasive monitoring systems that can monitor the status of a patient (ECG, body temperature, blood pressure, SpO2, accelerometer, etc.) for ubiquitous healthcare applications. Therefore, a low power operating ECG sensor board was developed for patient health monitoring, and the output of the ECG sensor board was connected to a USN platform.

5. Experimental Results

ECG data was obtained from the ECG signal generator via an ECG interface circuit, instead of an ECG sensor on the patient's body. The ECG signal generator generates a synthesized ECG signal with a user-settable heart rate, signal duration, sampling frequency, QRS waves, etc. The monitoring of vital signs during the wearing of the designed smart shirt was tested by real time monitoring of the ECG and acceleration signals of a wearer. For the simultaneous monitoring of physiological ECG data and the activity of the smart shirt wearer, a treadmill was used. The speed of the treadmill was controlled at a speed of 5km/h for walking and 8km/h for running. The system test on the treadmill was performed with the wearer standing motionless (resting), walking and running on the treadmill as shown in Figures.

Running Mode

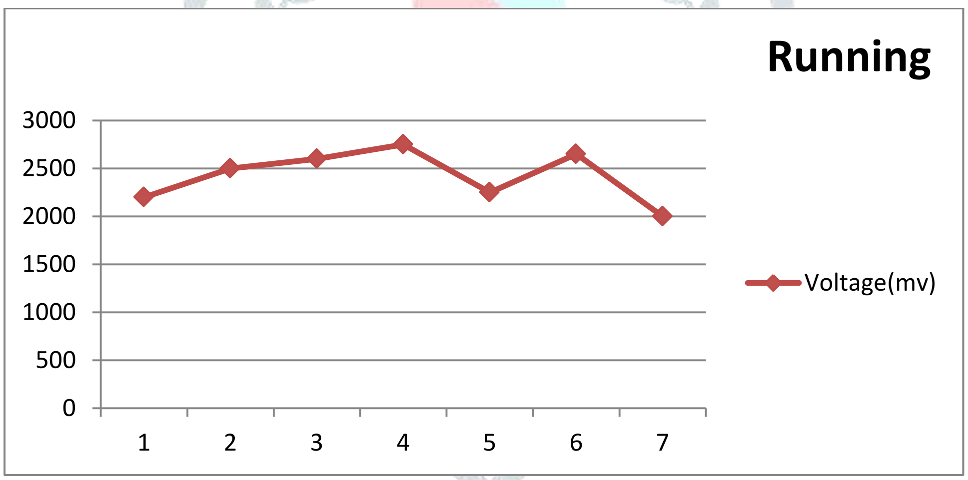

Figure 4: Running

The speed of the treadmill was controlled at a speed of 5km/h for walking and 8km/h for running. The system test on the treadmill was performed with the running on the treadmill as shown in Figure 6.

Walking Mode

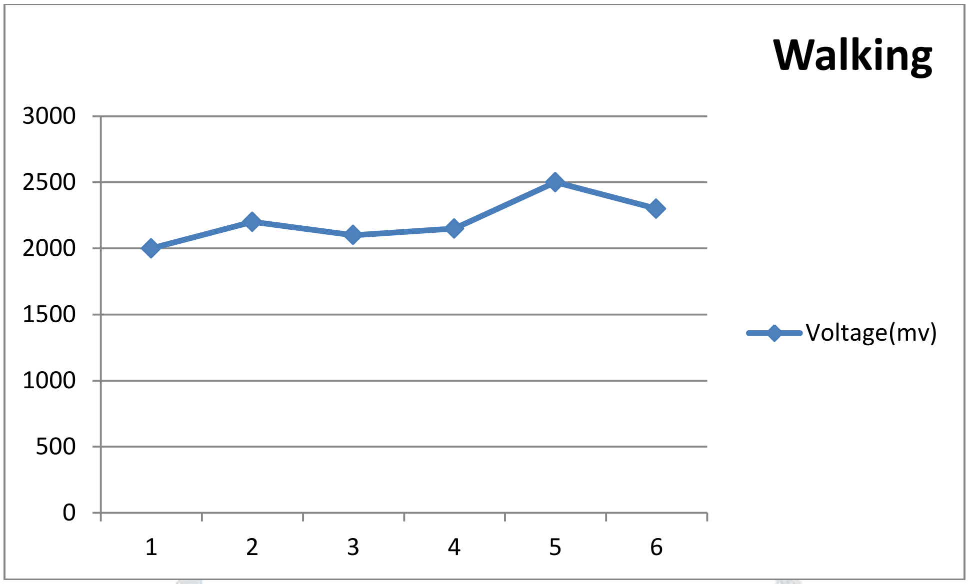

Figure 5: Walking

The speed of the treadmill was controlled at a speed of 5km/h for walking and 8km/h for running. The system test on the treadmill was performed with the walking on the treadmill as shown in Figure 6.

Resting Mode

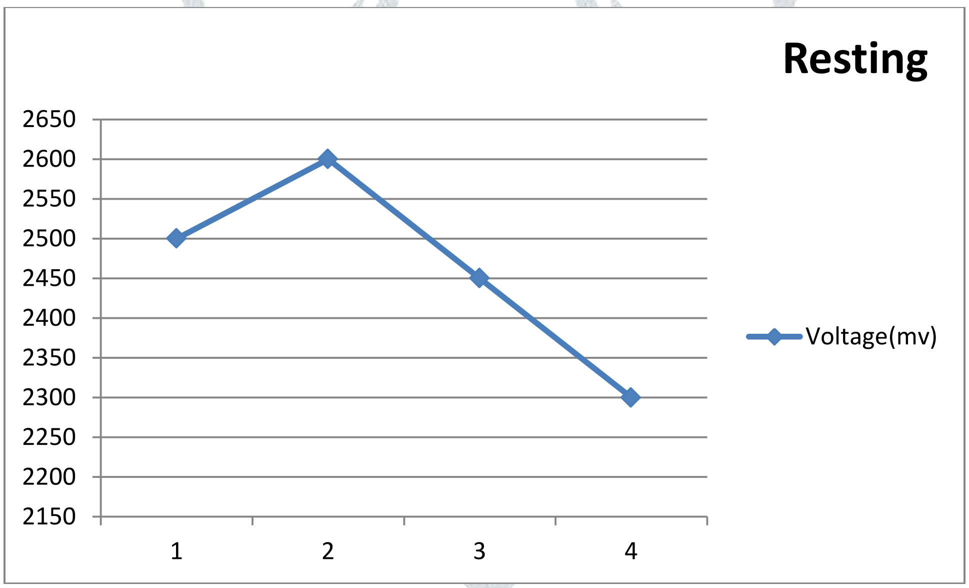

Figure 6: Resting

The speed of the treadmill was controlled at a speed of 5km/h for walking and 8km/h for running. The system test on the treadmill was performed with the wearer standing motionless (resting) on the treadmill as shown in Figure 6.

Conclusion

A wireless health monitoring system has potential to provide an improved service to patients, doctors and caregivers through continuous health monitoring. In addition, a smart shirt with wireless sensor network compatibility is designed and fabricated for the continuous monitoring of physiological ECG signals and physical activity signals from an accelerometer simultaneously. This paper produced an empirical analysis of the reliability of low-rate wireless ubiquitous healthcare monitoring applications. The experimental results are represented to running, walking, resting modes. Each modes are varied from ECG pulse rate measurements.

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