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Labview based Electrocardiograph (ECG) Patient Monitoring System For Cardiovascular Patient Using WSNs: A Critical Review

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Abstract: *Wireless Sensor Network is suitable a significant allowing technology for a wide variety of applications. Recent advances in wireless sensor networks have allowed the realization of prevalent health monitoring for both homecare and hospital environments. Current technological advances in sensors, power-efficient integrated circuits, and wireless communication have allowed the development of miniature, lightweight, low-cost, and smart physiological sensor nodes. These nodes are capable of sensing, processing, and communicating one or more vital signs. Furthermore, they can be used in wireless personal area networks or wireless body sensor networks for health monitoring. Many studies were performed and/or are under way in order to develop flexible, reliable, secure, real-time, and power-efficient wireless body sensor networks suitable for healthcare applications. To efficiently control and monitor a patient's status as well as to decrease the cost of power and maintenance, IEEE 802.15.4/ZigBee, a communication standard for low-power wireless communication, is developed as a new efficient technology in health monitoring systems. This paper describes the applications of wireless sensor networks in the healthcare area and discusses the related problems and challenges. The main goal of this review paper is to evaluate the acceptance of the current wireless standard for enabling wireless sensor networks for healthcare monitoring in real environment.*

Keywords: *Cardiac arrhythmias, Electrocardiogram , Discrete Wavelet Transform, P-QRS-T Segment, NI Lab VIEW Biomedical Toolkit, Biomedical workbench, ECG, Electrocardiograph parameters ECG Feature Extraction.*

I. INTRODUCTION

Wireless sensor networks have increased many different applications in such areas as health monitoring, industrial automation, military operations, building automation, agriculture, environmental monitoring, and multimedia. In particular, their application to healthcare areas received much care recently. The design and development of wearable biomedical sensor systems for health monitoring has drawn a particular attention from both university circles and industry. Medical technology has been contributing to the population aging. All over the world, populations are aging fast. According to the U.S. Census Bureau [U.S. Census Bureau, 2010], the population aged 65 years or over is 13 percent of the USA's population. Also, this rate is expected to increase up to 20 percent in 2050. Fast growing old people will motivation the increase in the expense of health care. Emerging patient-friendly medical equipment at a low price to provide the effective health care is a challenging task for medical service providers. Continuous real time health monitoring based on body sensor networks has a great potential for the care of patients. Because of this advantage, patients can be treated in a timely fashion, before some deadly event happens by continually monitoring the condition of patients and informing both the patients and medical professionals of any abnormalities. Body sensor networks consist of several distributed network devices containing sensor units, which collect and process data and communicate with other devices via a radio frequency channel .This wearable health monitoring system can monitor changes in a patient's vital signs and help patients maintain an optimal health status. Also, if patients wear wireless medical sensors for continuous monitoring, any emergency status detected by them can be sent to their doctors, hospitals, and other related medical entities when abnormal changes occur. This is helpful and can save the life when a patient has heart attack or treatment after surgery. A wireless physiological data monitoring system practices a radio channel to drive real-time vital sign data from wearable biomedical sensor to a coordinator. Patients can wear wireless devices that sense physiological conditions and send the sensed data to their doctors. Wireless health monitoring systems have several benefits compared to wire healthcare equipment, patients no waste waiting time to meet their doctor. Moreover, the use of wireless healthcare systems outer the hospital helps to save the healthcare cost for care providers. Also, it allows many patients to work while they are still under their doctor's care. Second, such systems can attentive any medical emergency if specific vital signs change drastically, e.g., heart rate is beyond the norm. A heart attack is the death of heart muscle from the sudden blockage of a coronary artery by a blood clot. If blood flow is not returned to the heart muscle within 30 to 40 minutes, unalterable death of the heart muscle begins to occur. Because heart attack suddenly happens to old people or patients, their continuous and real-time monitoring of heart rates can certainly help save their lives. Currently, most heart beat monitors, e.g., ECG are available at certain locations only, e.g., hospitals and doctor's offices. They require several wired electrodes on the skin of a patient. Professionals often use stethoscopes to check the heartbeat of a patient. Regrettably, these have critical limitation in heart beat nursing. As mentioned before, it is highly desired to monitor heart beat continuously for surprising heart attack. However, it is almost impossible with the existing wired medical equipment. Clearly, wireless health monitoring systems have many benefits compared to the current wired healthcare equipment.

In current years, Electrocardiography is the best usually used diagnostic tool in cardiology. It contributes considerably to the diagnostic and management of patients with cardiac disorders. Especially, it is essential to the diagnosis of cardiac arrhythmias and the serious myocardial ischemic syndromes .That's why it is critical to acquire accurate raw ECG signal caused by heart muscle, so that further signal processing can be performed with ease. Biomedical signal monitoring is a very important tool used to understand physiological mechanisms of the body and to diagnostic problems, particularly, ECG signal which has most valuable clinical regarding information. An extensive range of human physiological conditions can be contingent from the PQRST parameters obtained from an ECG recording instrument [1]. Various Instruments approves the development and implementation of innovative and cost-effective in biomedical applications and gives information management solutions in different manner. As the healthcare system continues to process to the growing trends of care and capitation, it is vital for clinically useful and very cost-effective technologies to be implemented and utilized accordingly our requirements. As application needs will surely continue to change, virtual instrumentation systems will continue to offer users flexible and powerful solutions without using new equipment or outdated instruments. The Biomedical Workbench in Lab VIEW Biomedical Toolkit provides applications for bio signal and biomedical image analysis. These applications make possible to apply biomedical solution using National Instruments software, such as National Instruments Lab VIEW hardware.

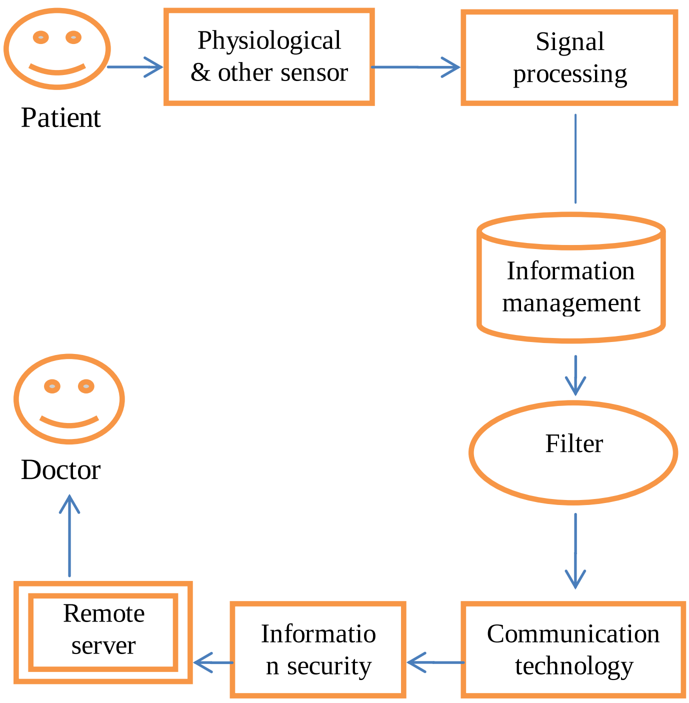

Figure 1: Architecture of remote health monitoring

User can acquire real world and real-time biomedical data by using biomedical sensors and National Instruments Lab VIEW hardware; also can import biomedical information from online data bank files, such Physic bank MIT-BIH database to the applications in this medical kit for analysis. Figure 1 shows a usual wireless sensor network for healthcare applications. In this network, the data collected by the sensor nodes are transmitted using an RF channel to the base station, coordinator or PDA/cell phone, which is connected to other networks via wired or wireless connection. The whole network is controlled and monitored by a server in real-time. Depend on an application, numerous transmission techniques are used for wireless communication such as Wi-Fi, Bluetooth, ZigBee, UWB, cellular networks, and Wireless sensor networks etc.

1.1 Physiological and Other Sensors

Today many sensors have been established which consumes less power, reduced size and low costs. This has simplified the researchers to progress the health monitoring systems which can be used at home by inserting these sensors in the patient's wearable [1]. From some select literature review, it looks that most of the physiological sensors such as Electrocardiogram, Respiratory, BP, Respiration Rate, Oxygen saturation, Temperature, Body impedance, and Heart Rate have been used separately or in combination to remotely monitor the health of patients. These sensors could be fixed in wearable garments, jewelry, clothing or beds for continual physiological measurements as well as environmental measurements to recognize a wearer's physiological parameter conditions. Blood Pressure sensor, galvanic skin sensors, flex sensors, piezo-electric & temperature sensors, EIP, and PPG [2] have also been used.

1.2 Data Processing Technologies

Data achievement from the sensors and signal processing has also been advanced from time to time. The most common components of this unit are signal amplification, noise deletion and its change from analog to digital form. The sensory signals so transformed into digital form are carried over as information over the radio. The analog signals after amplification and noise removal can directly be processed to remove important features and be processed further to diagnose the health condition of high risk patients who needs continuous attention. DSP makes it possible to implement these aspects using hardware/software tools. The advancement in embedded technologies such as hardware description languages, design tools to run and produce, concept of hardware-software co-design with the convenience of low power tiny processors makes many solutions to this process.

1.3 Information Management Technology

The digital information, the features take out and the diagnosis related measures need to be properly maintained at some temporary storage devices, before its remote transmission. Data combination from multiple sensors, decision making device & functional assessment components include PC, mobile devices, and PDAs.

1.4 Communication Technologies

Data transmission through wired or wireless media includes various technologies such as Bluetooth, Infrared, UWB (ultra wide band) & RF Communication, GSM & GPRS , CDMA, Wi-Fi / Wi-Max, WSNs etc.

1.5 Security Related Technologies

To secure the private information of patient of user from viruses & rejection of service attacks broken severs and firewalls introduced between consumer & remote server.

II. RELATED WORK

In this section some specific applications that have been developed or being researched for the health monitoring resolve are discussed. In Mobi Care [Rajiv, 2006], a wireless physiological measurement system (WPMS) as a Mobi Care client and health care servers services short-range Bluetooth between BSN and a BSN manager, and GPRS /UMTS cellular networks between the BSN manager and health care providers. Bluetooth is applied in this system, allowing data rate up to 1 Mbps. However, it consumes high power and has limited network size (up to 7 slave nodes). Thus, it does not suit for LR-WPAN (Low-rate WPAN) as required in many healthcare applications. Firefly is a sensor network-based rescue device used in coal mine as developed at Carnegie Mellon University [Mangharam, et al., 2006]. Voice pour out over WSN is implemented in this system. A TDMA based network scheduling is investigated to meet audio timing requirements. The developed hardware has dual architecture for data communication and hardware based time synchronization. This system is designed for the liberate in coal mine and has a small network size. It uses the chip and card for additional memory for sound transmission. It has high power consumption, high cost of a sensor, and bulky size.

The Code Blue [Malan, et al., 2004] projected from Harvard University explores WSN for a range of medical applications. It employs WSN in emergency medical care, hospitals and disaster area as an emergency message delivery system. With MICA motes, Code Blue uses pulse Oximetry and electrocardiogram (ECG) sensors to monitor and record blood oxygen and cardiac information from a large number of patients.
Lee et al. [2006] introduced a vital sign monitoring system with life emergency event detection using WSN. Dynamic signs such as ECG and body temperature of patients are transmitted wirelessly to the base station connected to a server or PDA. Dagtas et al. [2007]

presented a framework for a wireless health monitoring system within a smart home environment using ZigBee. They designed some basic processing platform that allows the heart rate and fatal failure detection. They are presently building a prototype of the proposed system using in-home ECG probes and ZigBee radio modules. In a wireless physiological sensor system, Jovanov et al. [2005] intended to develop wireless sensor technology for ambulatory and implantable human psycho physiological applications. They have developed the devices for checking the heart, prosthetic joints for a long period of time and other organs.

Chien and Tai [2006] proposed a prototype portable system to measure phonocardiography (PCG), ECG, and body temperature. They insert a capacitor-type microphone into the stethoscope's tube for PCG and develop a 3-wired lead ECG. Juyng and Lee [2008] described a device access control mechanism. They proposed the reliable data transmission of physiological health data in a ZigBee based health monitoring system. They developed a wrist, chest belt, shoulder, and necklace type physiological signal devices. They use a CC2430 microcontroller as the central unit and two PDMS (Polydimethylsiloxane) electrodes for ECG, a ribbon type temperature sensor, and SpO2 sensor for sensing the physiological signals. Their wrist type physiological signal device's (W-PSD) size is of 60*65*15 mm and total system weight is 160 g including one Lithium-polymer battery. A reliable data transmission mechanism is also provided by using a retransmission. They recognize the power problem for a network device. It needs small battery as its power source. It can work for 6 hours without replacement or recharging. It is small, lightweight, and easy to bring, but its life time from small battery should be improved. Bluetooth transceiver modules are used with a microcontroller and PDA for wireless between a identifying module and PDA.

Fensli, et al. [2005] presented a wearable Electrocardiogram device for continuous monitoring. The hand-held device, which is a common PDA, collects the amplified ECG signal from a wearable device. The sensor senses Electrocardiogram signals with 500 Hz sampling frequency, and this signal is digitized with 10 bit resolution. After digitizing the signal, it continuously transmits to a hand-held device by using a modulated RF link at 869.700 MHz. This system has focused its application on the backup situation. Monton et al. [2008] presented WPMS-based patient monitoring. This BSN follows a star network technology, and is composed of two types of modules. A small device called sensor communication module (SCM) is connected to one or several sensors for sensing the health signals. SCMs transmit signals to a central processing unit called personal data processing unit (PDPU) via ZigBee. PDPU is designed to connect to local external systems through: 1) UWB to connect individual devices such as PCs or PDA, 2) Wi-Fi to connect with LAN, or 3) GPRS for WAN.

The development of a belt-type wearable wireless body area network is described in [Wang, et al., 2009]. A photoplethysmograph (PPG) sensor and a respiratory inductive plethysmograph (RIP) sensor for pulse rate and oxygen saturation measurements are used for dynamic respiration monitoring. A WPMS node includes an MSP430F149 microcontroller as its main control unit, nRF905 as RF transceiver (915 MHz), and 64 Megabit AT25DF641 as external memory. They follow a simple communication protocol. Its overall process is very simple, i.e., one sensor to one base station at a time. Milankovic et al. [2006] proposed a single-hop Wireless sensor networks topology. Each sensor for health monitoring is directly connected to an individual PDA, which provides the connectivity to a central server. They mainly focus on the synchronization and energy efficiency issues on the single-hop communication network between network devices and PDA.

Table 1: Comparison of Electrocardiograph (ECG) Patient Monitoring System For Cardiovascular Patient Using WSNs

Reference	**Bio parameter**	**Hardware/data rate/distance**	**Wireless option**	**Network topology**	**Reliability**	**Portability**	**Interference /Collision**	**QOS**	**Network size**
Rajiv '06	Pulse rate, ECG, temp	Algorithmic P4032 board with R 5 MIPS, the RM 5231 from QED, 133 MHz	Bluetooth (BSN) with GPRS/UMTS Cellular network	Max 7 slave nodes to one PDA, BSN to cellular network	unknown	Not fully Developed.	Unknown	Not real time, selective data TX by user.	Small
Mangharam '06	Rescue in coalmine/	CC2420/Voice codec chip/SD card for memory	TDMA	Star	Fair	Poor (bulky size)	Poor	Continuous real time	Extremely small (one-to one)
Malan 04	Pulse Oximeter, ECG	Berkeley MICA mote(CC1000) with PDA/ 76.8 Kbps/ 20-30m	433/ 916 MHz	Ad-Hoc	Fair	Fair 5.7*3.2 *2.2 cm	Fair	Unknown	Big
Dagtas 07	ECG	M16C MCU/250 Kbps (802.15.4)	802.15.4/ ZigBee	Star/ Peer to Peer	Unknown	Unknown	Unknown	Unknown	Small
Chien 06	ECG , PCG, Temp	78E516B/Bluetooth transceiver, receiver/PDA/ memory/Microphone	Bluetooth	Max 7 slave nodes to one PDA	Poor	Poor (bulky size)	Fair Poor	(Single data TX)	Small
Oliver '06	ECG ,SpO2	DSP/ Bluetooth transceiver, receiver/Cell phone	Bluetooth	Max 7 slave nodes to one PDA	Fair	Poor	Poor	Real time	Small
Gyselinckx '07	ECG, EEG, EMG	MSP430/ nRF2401	2.4 GHz, TDMA	Star BSN to PDA	Fair	Fair 2 AA batteries 3 months	Fair	Fair	Med
Brown 09	ECG, EEG, EMG	MSP430/ nRF2401	2.4 GHz static TDMA	Star	Fair	Continuous real time	Fair	Continuous real time	Small
Fensli 05	ECG ECG sensor with hand-held device	879/700 MHz	GPRS/GMS	One sensor to hand-held dev.	Fair	Poor	Unknown	Real time Extremely	small (one-to one)
Milenkovic 06	ECG EMG,EEG	MSP430 with CC2420 ADXL202	ZigBee	Star, BAN with PDA	Good	Fair	Unknown	Real time	Med
Yan 07	ECG	MSP430F1611/ CC2420 4*4*0.2cm	IEEE 802.15 .4/	CDMA/WLAN Star/ CDMA(cell phone)	Good	Fair 4*4*0.2 cm	IEEE 802.15.4 with WLAN	Real time	Small
Juyng 08 .	PPG, ECG, Temp	CC2430 (sensor dev.) BIP-5000 (mobile)	ZigBee/ CDMA	Star (BAN)/ CDMA or WLAN	Good retransmission)	Good	IEEE 802.15.4 with WLAN Delayed	real time	Small

III. BLOCK DIAGRAM OF PROPOSED ECG DEVICES

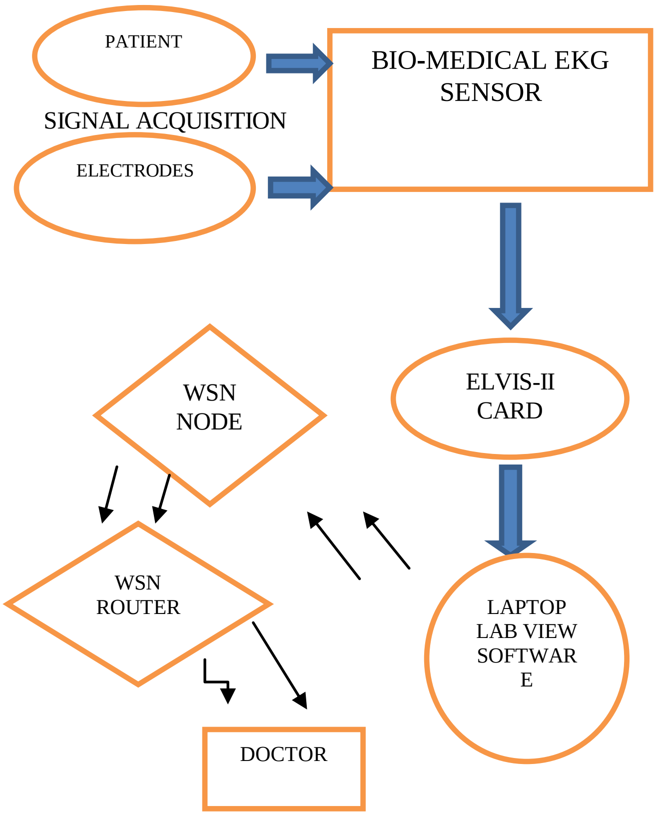

Figure 2: Proposed ECG Device system

The biomedical analysis process contains the following components

(a) Front End Devices, such as transducers and electrodes that user directly attach or connect to the subject. The front end might consist of preamplifiers and isolation circuits to guarantee the quality of the data acquisition.

(b) National Instruments DAQ Hardware & ELVIS Hardware that obtains data for analysis and processing. Various National Instruments DAQ hardware devices offer different specifications for sampling rate of system, resolution of the analog to digital converter and so on application.

(c) Signal Processing in Lab view software includes the Biomedical VIs and other signal processing tools in Lab VIEW. User can make customized VIs for processing bio signals and biomedical images and picture the analysis results in Lab VIEW software in bio medical kit.

(d) Biomedical Workbench hardware tool kit Ready-to-use applications for different acquired signal, preprocessing, extracting, and analyzing bio signals and biomedical images.

(e) Actuator Devices that transform electrical signals into certain kinds of motion or into physical signals. User can use the analog or digital output channels of NI DAQ hardware to drive an actuator.

IV. ECG BASICS

Electrocardiograph sends information regarding the electrical signal of the heart, by altering the shape of its principal waves, namely the P, QRS, and T waves. Electrocardiograph Feature Extraction shows a significant role in diagnosing most of the heart diseases. One cardiac cycle in an Electrocardiograph signal consists of the P-QRS-T waves. This paper presents a method to analyze electrocardiogram signal, over the features, for the classification of heart beats according to different arrhythmia. Cardiac arrhythmia which are create are Tachycardia, Bradycardia, Supra ventricular Tachycardia, Imperfect Packet Branch Block, Package Branch Block, Ventricular Tachycardia, therefore irregularities of heart may cause sudden cardiac diorder or cause damage of heart. The early recognition of arrhythmia is very significant for the cardiac patients. Electrocardiogram feature extraction system has been developed and evaluated based on the multi-resolution wavelet transform. An Electrocardiogram machine reads and records the electrical signal of the heart for diagnostic purposes. It is not a form of treatment for heart conditions. An electrocardiogram records the electrical activity of the heart. The heart produces minute electrical impulses which spread through the heart muscle to make the heart bond. These signals can be detected by the Electrocardiogram machine. An Electrocardiogram to help find the cause of indications such as palpitations or chest pain. The Electrocardiogram test is painless and meaningless (The Electrocardiogram machine records electrical impulses coming from your body) it does not put any electricity into your body [1]. The Electrocardiogram consists of several electrodes which are close to the body of the patient and are connected by wires to the device. The device itself consists of a graphing device (originally paper, although electric recorders are becoming more common). Each one of the sensors can sense a change in electrical charge in the skin that can only be the result of the impulses that are travelling through the heart and on to the relaxation of the body. It starts in the upper right ventricle, which contracts in response, and quickly travels through the other three chambers of the heart, which contract all at once.

This impulse trekking very fast and is also transmitted to the cells neighboring the heart as it dissolves throughout the body. This forms a very regular pattern which creates a control for patients that do have heart problems, such as arrhythmia. Electrocardiogram signals are recorded on paper chart or on a patient monitor. Electrocardiogram signal tracing are called by segments or wave.

An electrocardiogram (EKG sensor) is done to:
● Check correctly heart's electrical activity, how fast your heart is beating.
● Find the cause of chest pain, which could be caused by a heart attack, annoyance of the sac surrounding the heart (pericarditis), or angina.
● Find the cause of indications of heart disease, such as shortness of breath, dizziness, fainting, , irregular heartbeats (palpitations).
● Find the walls of the heart chambers are too thick (hypertrophied).
● Check how well medicines are working or not and whether they are causing side effects that affect the heart.
● Check how well mechanical devices that are fixed in the heart, such as pacemakers (parts), are working to control a normal heartbeat.
● Check the heart when new diseases or conditions are present, such as high blood pressure, high cholesterol, cigarette smoking, diabetes, or a family past of early heart disease.

An Electrocardiogram also can show:
● Lack of blood movement to the heart muscle (coronary heart disease)
● A heartbeat that's too fast, too slow, or irregular (arrhythmia)
● A heart that doesn't push forcefully enough (heart failure)
● Heart muscle that's too narrow or parts of the heart that is too big (cardiomyopathy)
● Birth defects in the heart (congenital heart disease)
● Problems with the heart valves (heart valve disease)
● Inflammation of such as surroundings the heart (pericarditis).

In recent years, Electrocardiography is the best commonly used diagnostic tool in cardiology. It supports significantly to the diagnostic and management of patients with cardiac disorders. Mainly, it is essential to the diagnosis of cardiac arrhythmias and the acute myocardial ischemic syndromes .That’s why it is critical to acquire accurate raw Electrocardiogram signal caused by heart muscle, so further signal processing can be performed with ease. Biomedical signal monitoring is an effective tool used to know physiological workings of the body and to diagnose potential problems, particularly, Electrocardiogram signal which has valuable clinical information. A wide range of human physiological conditions can be inferred from the PQRST parameters obtained from an Electrocardiogram recording instrument. Virtual Instrumentation permits the development and implementation of innovative and cost-effective biomedical applications and information management solutions. As the healthcare industry remains to respond to the rising trends of managed care and capitation, it is imperious for clinically useful, cost-effective technologies to be developed and utilized. As application requirements will surely continue to change, virtual instrumentation systems will continue to offer users flexible and effective solutions without requiring new equipment or traditional instruments.

The Biomedical Workbench in Lab VIEW Biomedical Toolkit provides applications for bio signal and biomedical image examination. These applications make possible to apply biomedical solution using National Instruments (NI) software, such as lab VIEW with National Instruments hardware. User can use these applications to screen and play bio signals, simulate and generate bio signals, evaluate bio signals, and view biomedical imagery [3]. User can acquire real world and real-time biomedical data by using biomedical sensors and National Instruments hardware; also can import biomedical information from online data bank files, such as Physio bank MIT-BIH database to the applications in this kit for analysis.

National Instruments (NI) hardware and the applications in this kit can also be used to generate standard analog biomedical signals to authenticate and test biomedical instruments [3]. The analysis and processing of bio signals and biomedical images can provide useful information for recognizing, visualizing, and understanding biomedical characteristics in human bodies and in animal bodies.

The Lab VIEW Biomedical Toolkit includes tools that can be used to obtain, preprocess, extract, and analyze bio signals and biomedical images. By using the Biomedical Toolkit with National Instruments DAQ hardware, user can set up a system for learning signal processing techniques in bioinstrumentation and also can use different signal processing methods in research and academic projects related to biomedical engineering and other biomedical fields [4].

V. THE ECG WAVEFORM

Discussing to “Principles of Electrocardiography,” Electrocardiogram signals typically range from ±2mV, with a required bandwidth of 0.05 to 150 Hz. The article also confers the details of a normal recording as shown in Figure 4. Electrocardiogram signal consists of

P wave, QRS complex and T wave. The human heart beat is started by the P wave which shows the activation of atriums depolarization. It is here when the heart begins its beat. Following the P wave is the QRS complex. In this part of the heartbeat, potentials coming from the ventricles depolarize right before their contraction. Finally the T wave comes from the polarization of the ventricle muscles cells, coming back into stable stage for another contraction. The QRS complex is a very main part of the Electrocardiogram signal, which conveys a number of significant parameters of cardiac arrhythmia. The duration of the QRS complex is the basis for the characterization of an Electrocardiogram signal because it is here where we can measure the time it takes for the ventricles to depolarize. Also, the distance between two R peaks is frequently used as the basis to determine the pulse rate of the patient. The cardiac mechanism of an Electrocardiogram is shown in Figure the above waveform shows an Electrocardiogram shows the cardiac cycle. The cardiac sounds are also shown. The bottom waveform shows that ejection occurs when the pressure in the left ventricle exceeds that in the arteries. This gives the researchers information on how abnormal heartbeats produce distorted QRS waveforms. A research allowed "Clinical Electrocardiography and Arrythmias" by Professor Roger Mark (2004) of the Massachusetts Institute of Technology gives understanding in the irregularities that can be observed in an electrocardiogram wave signal and what diseases these anomalies represent. The myocardial muscle mass changes depending on the kind of disease, and when myocardial muscle mass vagaries, the Electrocardiogram is also altered.

For example, large QRS amplitude means there is an rise in ventricular muscle mass or also known as hypertrophy. Also, any alteration in the morphology of the QRS complex incomes that there is a dead heart muscle replaced by scar tissue such as myocardial infarctions.

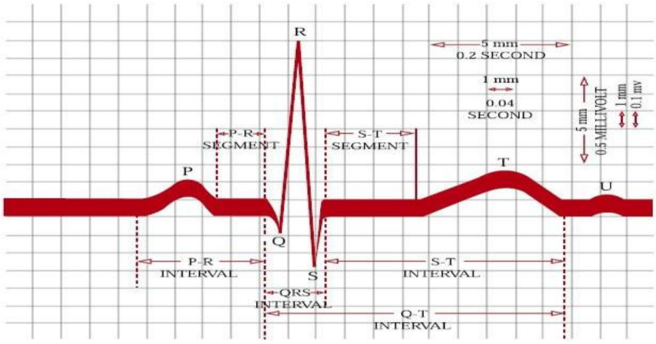

Figure 4: Recording Conventions, Waveform Nomenclature, and Normal Values for ECG

According to Mark, electrocardiographic equipment is typically adjusted so that the vertical distance between two together lines represents 0.1 millivolt and the horizontal Distance between two together lines represents 0.04 seconds. The lines on standard graph paper are one millimeter apart. For example, a one millivolt waveform lasting 0.2 seconds will stand 10 millimeters tall and 5 millimeters wide. Figure illustrates the conventions regarding the voltage and time calibrations, whereas Table shows the usual ranges of the P-R, QRS, and Q-T Intervals, and S-T Segments with the calculation for heart rate for adults and children..

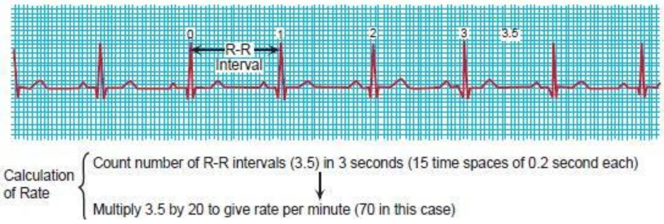

Figure 5: Calculation of Heart Rate

Calculation of a person's heart with his Electrocardiogram is based on the formula of Rate = 60xR-R Interval. R-R Interval is the amount of time in seconds between two R peaks. This formula was applied in determining the heart rate of a patient.

VI. RESEARCH ISSUES

A number of aspects should be considered when developing a miniature wireless sensor device and network for a real life health monitoring system.

6.1 Reliability

Reliability in a wireless health monitoring system is the most critical issue. Wireless health monitoring systems have to accurately transmit measured data in a timely manner to a medical doctor or other people for monitoring and analyzing the data from patients.

The reliability issue can be considered in three main stages:

1) Reliable data measurement,
2) Reliable data communications, and
3) Reliable data analysis [Hyun, et al., 2008].

Stages 1 and 3 are mainly about hardware and software for sensing and analyzing the data without errors. Stage 2 needs more consideration than the other stages because it is about communication between a sensor node and coordinator or central monitoring server. For reliable communication, Varshney [2007] proposed combined wireless networks that include wireless sensor networks, ad-hoc wireless networks, cellular networks, WLAN, and satellite networks. Juyng and Lee [2008] made a reliable data transmission by using a retransmission protocol. A sensor device sends the data with Acknowledgement request. If the sensor node doesn't receive an Acknowledgement from a mobile device or coordinator within Acknowledge Wait Duration, it transmits the same data frame again till it receives the Acknowledgement from the mobile device. This repeating process is limited by predefined Max Frame- Retries [IEEE Std. 802.15.4-2003].

6.2 Power

The power issue is researched for all kinds of wireless sensor networks applications. Since most wireless sensor networks devices are battery-operated, one of the major challenges for their design is to optimize their power usage. Some wireless sensor networks applications such as passive RFID [RFID Handbook, 2003], do not require battery. Instead they use power from their reader, i.e., backscattering. However, they have limited communication range and can carry very small size data only. Other applications adopt energy harvest systems for wireless sensor networks such as solar cell [Hande, et al., 2007], vibration using piezoelectric devices [Roundy and Wright, 2004], temperature difference [Stark, 2006], and shoes insert [Paradiso and Starner, 2005]. But these energy harvest systems have some problems for real wireless sensor networks applications, e.g., their power earning depends on their environment and they tend to be over-sized.

Table 2: Normal Values for ECG

Normal range	P-R interval	QRS interval	Rate	Q-T interval	S-T interval
Adults	0.18-20 S	0.07-0.10	60	0.33-0.43	0.14-0.16
Children (Rate :70)	0.15-0.18		70	0.31-0.41	0.13-0.15
Children (Rate :80)			80	0.29-0.38	0.12-0.14
Children (Rate :90)			90	0.28-0.36	0.11-0.13
Children (Rate :100)			100	0.27-0.35	0.10-0.11
Children (Rate :120)			120	0.25-0.32	0.06-0.07

Van Dam and Langendoen [2003], Zheng, et al. [2005], Rama krishnan, et al. [2004] and Miller and Vaidya [2005] presented energy efficient protocols for wireless sensor networks by designing energy-efficient MAC protocols. Omeni et al. [2007] proposed to control standby or sleep mode periods of sensor nodes to reduce energy consumption. They propose MAC protocol operations based on three main communication processes. A link establishment process is to associate a process to a network. A wakeup service process is to wake up a slave and master after an assigned sleep time interval. An alarm process operates only when a slave node urgently wants to send data to the master. These processes can be initiated by the master node only.

6.3 Portability

Integration of sensing components into a wireless sensor node should be conducted in a functional, robust, small, light-weight, and low-cost way. For this reason, most PANs use a small chip system, i.e., SOC, which includes a microcontroller and RF transceiver or single MCU with an external transceiver. Currently, there are some biomedical systems that suit the requirements of easy-to-wear or attach on the body for monitoring physiological signals [Barth, et al., 2009; Jung. et al., 2008].Thus they exhibit good portability.

6.4 Network Interference

In general, a wireless link is more sensitive to interference than a wired one. In WSN environments, usually two or more different communication techniques are used together in a same network. Usually, WPANs and WLANs consist using the same Industrial, Science and Medical (ISM) band. Therefore, they can prime to a network interference problem. Network interference or data collision problems cause intermittent network connectivity, packet loss and ultimately result in lower network throughput and increased energy expenditures [Razvan and Andreas, 2008]. The interference and coexistence problems between Bluetooth and WLAN have been presented in [Jo and Jayant, 2003; Sakal and Simunic, 2003; Howitt, 2001; Feng, et al., 2002]. Interference problems between IEEE 802.15.4/ZigBee and WLAN are described in [Razvan and Andreas, 2008; Kim, et al., 2005; Kang, et al., 2007; Yang and Yu, 2009; Hauer, et al., 2009]. BER (Bit Error Rate), PER (Packet Error Rate), RSSI (Radio Signal Strength Indicator), or SINR (Signal Interference Noise Ratio) for interference avoidance are measured and analyzed. Guo and Zhou [2010] proposed interference prediction algorithms to explore the impacts of WiFi and microwave oven on ZigBee communications based on observations of the packet error rate.

6.5 Real Time and Continuous Monitoring

Some physiological data, such as heart beat sound, lung sound, ECG, and RIP, should be monitored continuously and in real time. Also, a biomedical sensor is unreal to operate for days, sometimes, weeks without a user's intrusion. A good example is a heartbeat monitoring system for a patient who has heart disease.

Since the heart rate is testified periodically, a heartbeat sensing device should be always on and transmit continuously with low transmit time delay and latency for real time monitoring. If a sensing device could transmit periodic data discontinuously or transmit continuous data with has much delay time, it is hard for doctors to monitor and prepare a patient's heart attack. Therefore, real-time and continuous monitoring is serious in handling a critical patient.

6.6 Limitations and Challenges in WSN

Several current researches or prototypes of their medical applications and issues mentioned. From it, most applications use MCU as a control unit to achieve low power consumption, and small device size. Also, all devices receive the power from batteries such as AAA, AA, and Li-ion. Size and weight of devices are mainly determined by those of the batteries. A battery's capacity is directly proportional to its size. Malan, et al. [2004], Oliver and Msngas [2006], Gyselinckx, et al. [2007], and Milenkovic, et al. [2006] use 2 AA or 2 AAA battery and [Juyng and Lee, 2008] and [Monton, et al., 2008] use the Li-ion or Li-P battery. A small Li-P battery's life time [Juyng and Lee, 2008] is about 6 hours, while AA or AAA battery's life time is several days or even 3 months in a full active mode [Gyselinckx, et al., 2007]. Therefore, battery types need be carefully selected for portability and power consumption of different healthcare applications. Some applications implement several wireless infrastructures for health monitoring systems. Rajiv [2006], Chien and Tai [2006], and Oliver and Msngas [2006] apply Bluetooth to WSN with PDA, Cell phone, or WLAN. Milenkovic, et al. [2006], Yan and Chung [2007], and Juyng and Lee [2008] apply ZigBee to BAN with PDA, or WLAN for extended network size. When several wireless infrastructures are deployed in the same network area, interference and data collision can occur in their overlapped channels. Different network topology, such as star, peer-to-peer, and mesh, should be considered for different health data applications. Table 3 summarizes the platforms for physiological data sensing and monitoring with several wireless options. Each project addresses some above-mentioned issues, such as reliability, power, portability, network interference, and QoS, for real life. But none satisfies all of them. For example, some applications [Jung, et al., 2008; Milenkovic, et al., 2006] have good reliability, portability, and QoS, but their power consumption is not suitable for real life applications. Some applications [Mangharam, et al., 2006; Chien and Tai, 2006; Oliver, et al., 2006] have good performance, but their devices are too big and heavy to carry or attach on the body in real life applications. FireFly project [Mangharam et al., 2006] can send the continuous voice data in real time, but they have high power consumption, bulky size device and small network size. Clearly, current health monitoring still has many challenges and issues that must be addressed such as reliability, portability, low-power consumption, and real-time communication as discussed. Most reviewed systems focus on single hop topologies, and have very limited real-time monitoring capability. Also, some systems are hard to attach or carry because of their size and weight. Even if they can monitor the health conditions, they cannot be readily available for real life applications. They use different wireless technologies for their different health parameters, situation, and areas. For example, some small data such as body temperature and patient ID are communicated by IEEE 802.15.4/ZigBee, even if this standard has low data rate. Also, these kinds of data are not much affected by time synchronization in real time. But some physiological data such as ECG, EEG, and EMG, need continuous and real-time transmission. Also, they require high data rate for reliable transmission. As such, each application on a health monitoring system has to consider or improve their weak points for real-life use.

CONCLUSION

A wireless Electrocardiogram monitoring device using wireless sensor networks technology was designed, constructed, and implemented. The device could remotely measure and monitor the heart rate and rhythm of a person at a specific distance. The advanced analysis techniques available on the computer are becoming invaluable to the practicing physician as well as researchers. The diagnostic decision will be more accurate. Peak detection in electrocardiogram is one of the solved problems using Lab VIEW. Clinical applications and research studies both apply heart rate unpredictability analysis results for statistical and frequency methods. Electrocardiogram monitoring device using wireless sensor networks technology was designed, constructed, and implemented. The technique is user-friendly, low cost and hence anyone septic of heart problem can analyze Electrocardiography using this efficient method. In this paper, the low-cost biomedical measurement with help of system with the capability of storage in digital format as well as transmitting the data to the remote area has been presented. The ECG measurement system is also capable of sending the data through wireless sensor networks to the physician or health care center with no time. The ECG system could be modified by increasing the number of channels and improves the cover distance between patient to doctor.

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