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ZIGBEE BASED WIRELESS PATIENT MONITORING

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***Abstract*—**
Patient monitoring systems are gaining their importance as the fast-growing global elderly population increases demands for caretaking. These systems use wireless technologies to transmit vital signs for medical evaluation. This paper describes the design of a wireless sensor network based on zigbee technology using master and slave communication. It is mainly used for collecting and transferring the various monitoring information about the patients in hospitals or in their homes. This application consists of Zigbee based network, four types of sensors, master, two submaster and slave combination. Since the whole area cannot be covered by a single Master slave combination .For this purpose a master and slave combination is used. Also the cooperative communication technique is used to make sure that the slave is always in range of the master. For this purpose two sub masters units are used. Here the main PC master terminal has the Visual Basic software on it .The PC master terminal is used to monitor the status of all the slaves which covers the whole area. Hence the transmission scheme ensures the successful transmission of these critical messages. It is fast and reliable.

Keywords-Cooperative communication, Patient Monitoring, Wireless Sensor, Zigbee Technology

I. INTRODUCTION

Patient monitoring systems become a important topic and research field today. Research on health monitoring were developed for many applications such as military, homecare unit, hospital, sports training and emergency monitoring system. Patient monitoring systems are gaining their importance as the fast-growing global elderly population increases demands for caretaking. These systems use wireless technologies to transmit vital signs for medical evaluation. This paper describes the wireless sensor network based on ZigBee technology. It is mainly used for collecting and transferring the various monitoring information about the patients in hospitals or in their homes. This application consist of Zigbee based network, four sensors, master, two submaster and slave combination. It is mainly used to monitor pulse rate, ECG, temperature and triaxial accelerometer movement of the patient. For this purpose a master and slave combination is used. The pulse rate and triaxial accelerometer sensors are connected to one slave and ECG and temperature sensors are connected to one slave. Each slave consists of two sensors, Zigbee transreceiver, ARM microcontroller and LCD. Data is digitized with an arm microcontroller and send to a computer by using zigbee transreceiver. Also the cooperative communication technique is used to make sure that the slave is always in range of the master. For this purpose two sub masters units are used. Each submaster consists of ARM microcontroller and zigbee transreceiver. Here the main PC master terminal has the Visual Basic software on it which shows the patients current status. The PC master terminal is used to monitor the status of all the slaves with the help of zigbee transreceier which covers the whole area. Also provides alert to medical staff when patients pulse rate, triaxial accelerometer movement, ECG and body temperature falls outside of normal bounds. Hence the transmission scheme ensures the successful transmission of these critical messages. It is fast and reliable.

II. LITERATURE REVIEW

Currently, a number of studies have been proposed to address the issues of transmitting vital signs in nursing homes , homes and hospitals over wireless transmission. Patient monitoring systems [1] are gaining their importances the fast-growing global elderly population increases demands for caretaking. These systems use wireless technologies to transmit vital signs for medical evaluation**.** According to Kinsella and He's [2] report from the US Census Bureau, the global elderly population is fast growing and will outnumber the population of children in near future. The aging society is bringing its impact on many developing countries and presents a stark contrast with the low fertility rate of these countries. The changes brought about by the aging society include an increasing demand for caretaking; thus, patient monitoring systems are gaining their importance in reducing the need for human resources. Caretaking homes and hospitals have been planning on the use of biological sensors to effectively minister to their patients. Vital signs, such as body temperature, blood pressure, and sugar level, can be regularly collected and remotely monitored by medical professionals, achieving a comprehensive caretaking system.

ZigBee [3] is an open standard technology to address the demands of low-cost, low-power WMNs via short range radio. ZigBee [4] is targeted at RF applications that require a low data rate, long battery life, and secure networking. Its mesh networking also provides high reliability and more extensive range. The ZigBee devices can be combined with WWANs to achieve a seamless platform of wireless patient monitoring. The ECG and heart rate data can not only help the caregivers to know the urgency of the fall-induced injury, but also show

the probable reasons of falls. IEEE 802.15.4 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). It is maintained by the IEEE 802.15 working group. It is the basis for the ZigBee.

Varshney [5] proposed a framework of patient monitoring systems, including patient monitoring devices, ad hoc wireless networks, and the receivers for healthcare professionals. This framework uses four routing schemes (multicast, reliable multicast, broadcast, and reliable broadcast) and several enhancing schemes to improve the transmission reliability over wireless ad hoc networks.

Jovanov *et al.* [6] present wireless distributed data acquisition system. The system uses personal digital assistant as a mobile client to acquire data from individual monitors and synchronizes collected records with existing records on the telemedical server. Each client device uses local flash memory as a temporary storage until reliable connection with a mobile client is established.

Istepanian and Petrosian [7] present an optimal zonal wavelet-based ECG data compression method, which reaches a maximum compression ratio of 18:1 with low-percent rms difference (PRD) ratios for a mobile telecardiology model. The method also attains an ambulatory speed of up to 100 km/h in urban channel profiles with a bit error rate of less than 10−15 and with an average reduction of 73% in the transmission time.

Varshney and Sneha [8] proposed protocols for power management under varying user densities, power levels, and numbers of hops to support a diversity of devices. Their scheme provides a reliable message delivery at reasonable transmitted power.

Cypher *et al.* [9] surveyed previous work on wireless communications in support of healthcare networks. The authors only consider the case of one-hop transmission. From an analytical perspective, while using IEEE 802.15.4 standard for ECG, the maximum payload size only allows up to 118 samples per frame bringing the accumulation delay 236 ms. The minimum data sampling rate of 1 sample per frame results in an accumulated delay of 2 ms.

III. System Overview

Patient monitoring systems are gaining their importance as the fast-growing global elderly population increases demands for caretaking. This paper describes the wireless sensor network based on ZigBee technology. It is mainly used for collecting and transferring the various monitoring information about the patients in hospitals or in their homes. It is mainly used to monitor pulse rate, ECG, temperature and triaxial accelerometer movement of the patient.

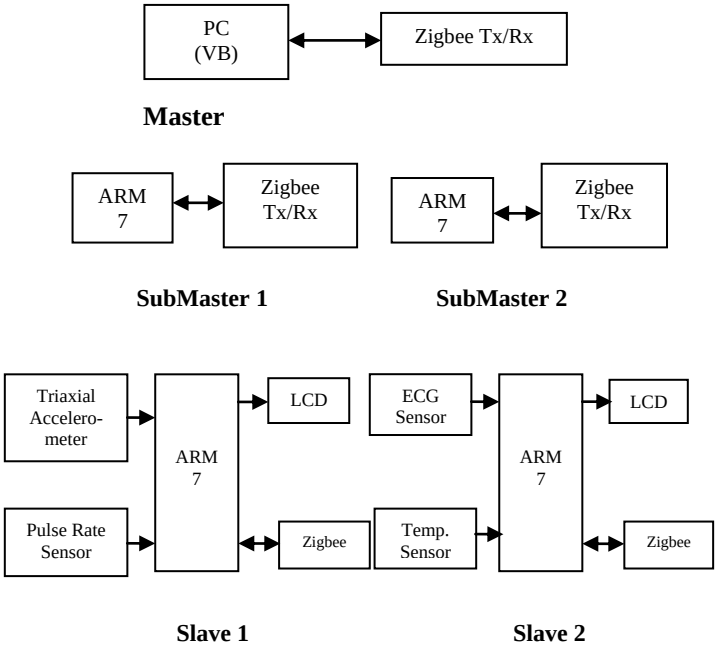

Figure1. Block Diagram of Wireless Patient Monitoring

Figure 1 shows the block diagram of wireless patient monitoring. This application consist of Zigbee based network, four types of sensors, master, submaster and slave combination. Since the whole area cannot be covered by a single Master slave combination .For this purpose a master and slave combination is used. The pulse rate and triaxial accelerometer sensors are connected to one slave and ECG and temperature sensors are connected to one slave. Each slave consist of two sensors, zigbee transreceiver, ARM 7 microcontroller and LCD. Data is digitized with an ARM microcontroller and send to a computer by using zigbee transreceiver. The range of zigbee is about 30 mtrs to 1km hence it is preferred. We have a main PC master terminal which has the VB software on it .The PC master terminal is used to monitor the status of all the slaves which covers the whole area. Also provides alert to medical staff when patients pulse rate, triaxial accelerometer movement, ECG and body temperature falls outside of normal bounds.

In this system the Master sends the request to the all the slaves. In the request frame the master mentions the slave ID .The request frame is received by all the slaves which are in range .The slave who are in range receive the incoming frame and store it in its internal RAM memory .Then they check for the slave ID .If the incoming slave ID matches with their own slave ID then they Accept the frame and send the parameter back to the master .If the ID does not match then the slave discards the frame.

So in total there are 2 slaves. The Idea is that if one slave goes out of range of the PC then the communication fails .So we are placing 2 slaves which will be placed in such way that they will be always in range of the PC master .The two slaves are under the PC based masters supervision .Therefore the PC

master will communicate to the slaves via Wireless Zigbee module.

Cooperative Communication

Here cooperative communication technique to make sure that the slave is always in range of the master. For this we use two sub masters units. These units are basically repeater unit which will enhance the data signal when the slave is not in range of the master. Here the request is first given to the sub master. The frame transmitted by PC master will contain the sub master ID as well as the slave id from whom the data is to be retrieved.

The sub master upon receiving the frame will then check for the slave ID and will retransmit the frame as it is. If one of the sub masters fails then the other sub master can also send the data of the other slave. Hence the transmission scheme ensures the successful transmission of these critical messages. It is fast and reliable.

IV. HARDWARE

In this paper hardware used is Zigbee, LCD, ARM 7 microcontroller, pulse rate sensor, triaxial accelerometer, ECG sensor and temperature sensor.

A. ZIGBEE

ZigBee is a low-cost, low-power, wireless mesh networking proprietary standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications, the low power-usage allows longer life with smaller batteries, and the mesh networking provides high reliability and larger range. Range of Zigbee is from 30 meters-1km.The technology is intended to be simpler and less expensive than other WPANs such as Bluetooth. Its protocols are intended for use in embedded applications requiring low data rates and low power consumption. Its current focus is to define a general-purpose, inexpensive, self-organizing mesh network that can be used for industrial control, embedded sensing, medical data collection, smoke and intruder warning, building automation, home automation, etc. Specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. ZigBee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones. This allows ZigBee networks to be formed ad-hoc, with no centralized control or high-power transmitter/receiver able to reach all of the devices. It is targeted at applications that require a low data rate, long battery life, and secure networking. It has a defined rate of 250kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. consumer and industrial equipment that requires short-range wireless transfer of data at relatively low rates. transmission rates vary from 20 to 900 Data rates of 250 kb/s, 40 kb/s and 20 kb/s Home networking, automotive networks, industrial networks, interactive toys, remote metering, battery operated products, building automation, personal healthcare, industrial control, residential or light commercial control, consumer electronics, PC and peripherals, etc.

IEEE 802.15.4

IEEE 802.15.4 is a standard which specifies the physical layer and media access control for low-rate wireless personal area networks (LR-WPANs). It is maintained by the IEEE 802.15 working group. It is the basis for the ZigBee , Wireless HART, and MiWi specifications, each of which further extends the standard by developing the upper layers which are not defined in IEEE 802.15.4.Its license free frequency bands are:

2.4 Ghz (16 channels with baud rate of 250 kbps)
902 Mhz – 928 Mhz (10 channels with baud rate of 40 kbps)
868 Mhz- 870 Mhz (1 channel with baud rate of 10 kbps)

North America, Australia, Europe and New Zealand use the sub 1 Ghz bands whereas the rest of the world uses the 2.4 Ghz bands.

Zigbee/IEEE 802.15.4 Architecture

Figure 2 shows the architecture of zigbee which consists of Application, Zigbee alliance, IEEE 802.15.4 MAC and PHY layers.

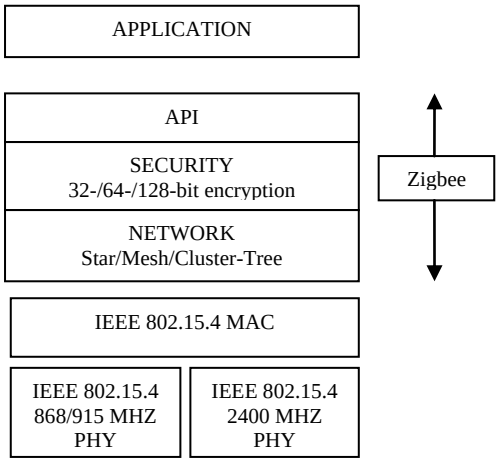

Figure2. Architecture of Zigbee/IEEE 802.14.5

The Physical Layer

The physical layer (PHY) ultimately provides the data transmission service, as well as the interface to the physical layer management entity, which offers access to every layer management function and maintains a database of information on related personal area networks. Thus, the PHY manages the physical RF transceiver and performs channel selection and energy and signal management functions.

The MAC layer

The medium access control (MAC) enables the transmission of MAC frames through the use of the physical channel. Besides the data service, it offers a management interface and

itself manages access to the physical channel and network beaconing. It also controls frame validation, guarantees time slots and handles node associations. Finally, it offers hook points for secure services.

Zigbee Alliance

The Zigbee alliance consist of API, security which includes 32-/64-/128- bit encryption and network which includes star, mesh and cluster tree. Above this layer is application layer.

B. ARM 7Microcontroller

The LPC2131/32/34/36/38 microcontrollers are based on a 16/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine the microcontroller with 32 kb, 64 kb, 128 kb, 256 kb and 512 kb of embedded high-speed flash memory. A128-bit wide memory interface and a unique accelerator architecture enable 32-bit code execution at maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty.

Due to their tiny size and low power consumption, these microcontrollers are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. With a wide range of serial communications interfaces and on-chip SRAM options of 8kB, 16 kB, and 32 kB, they are very well suited for communication gateways and protocol converters, soft modems, voice recognition and low-end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit 8-channel ADC(s), 10-bit DAC, PWM channels and 47 GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers particularly suitable industrial control and medical systems.

C. SENSORS

The following types of sensors are used. They are as follows:

1. Pulse Rate Sensor

The pulse rate sensor is basically used to keep track on the pulse rate of the person. In programming the maximum and the minimum set point are provided for the pulse rate. If the pulse rate goes below or above the set point then the alert will be immediately issued by the microcontroller.

2. Triaxial Accelerometer

An accelerometer is an electromechanical device that will measure acceleration forces. These forces may be static, like the constant force of gravity pulling at your feet, or they could be dynamic-caused by moving or vibrating the accelerometer. Accelerometer use the piezoelectric effect- they contain microscopic crystal structures that get stressed by accelerative forces, which cause a voltage to be generated. The three axis accelerometer are basically used to identify the movements across the three axis i.e. x-axis, y-axis, z-axis. Accelerometer is an electronic device which is interfaced using I2C protocol and provides the reading after every 1msec. According to the requirement of the application the microcontroller will take the reading from the accelerometer within a fixed interval of time. Triaxial accelerometers measure the vibration in three axes X, Y, and Z. They have three crystals positioned so that each one reacts to vibration in a different axis. The output has three signals, each representing the vibration for one of the three axes.

3. ECG Sensor

An ECG sensor is the best way to measure and diagnose abnormal rhythms of the heart, particularly abnormal rhythms caused by damage to the conductive tissue that carries electrical signals, or abnormal rhythms caused by electrolyte imbalances. In a myocardial infarction (MI), the ECG can identify if the heart muscle has been damaged in specific areas, though not all areas of the heart are covered. The ECG cannot reliably measure the pumping ability of the heart, for which ultrasound-based (echocardiography) or nuclear medicine tests are used. It is possible for a human or other animal to be in cardiac arrest, but still have a normal ECG signal (a condition known as pulse less electrical activity). The ECG device detects and amplifies the tiny electrical changes on the skin that are caused when the heart muscle depolarizes during each heartbeat.

4. Temperature Sensor

Temperature sensor is used to sense the temperature. It can sense the temperature of the atmosphere or the temperature around it or the temperature of any machine o to which it is connected or even can give the temperature of the human body. It is an analog sensor and gives the output into form of analog signal. This signal is feed to ADC which will convert it into digital form. Once converted into analog form the microcontroller can process the digital temperature signal as per the application.

D. LCD

The LCD is used to visualize the output of the application. It is used to check the output of different modules interfaced with the microcontroller. Thus LCD plays a vital role to see the output and to debug the system module wise in case of system failure in order to rectify the problem.

V. SOFTWARE

Here visual basic software is used on the PC master side. The figure 3 shows the flowchart of the wireless patient monitoring. Here the Master sends the request to the all the slaves. In the request frame the master mentions the slave ID .The request frame is received by all the slaves which are in range .The slave who are in range receive the incoming frame and store it in its internal RAM memory. Then they check for the slave ID .If the incoming slave ID matches with their own slave ID then they Accept the frame and send the parameter back to the master .If the ID does not match then the slave discards the frame. So in total there are 2 slaves if one slave goes out of range of the PC then the communication fails .So

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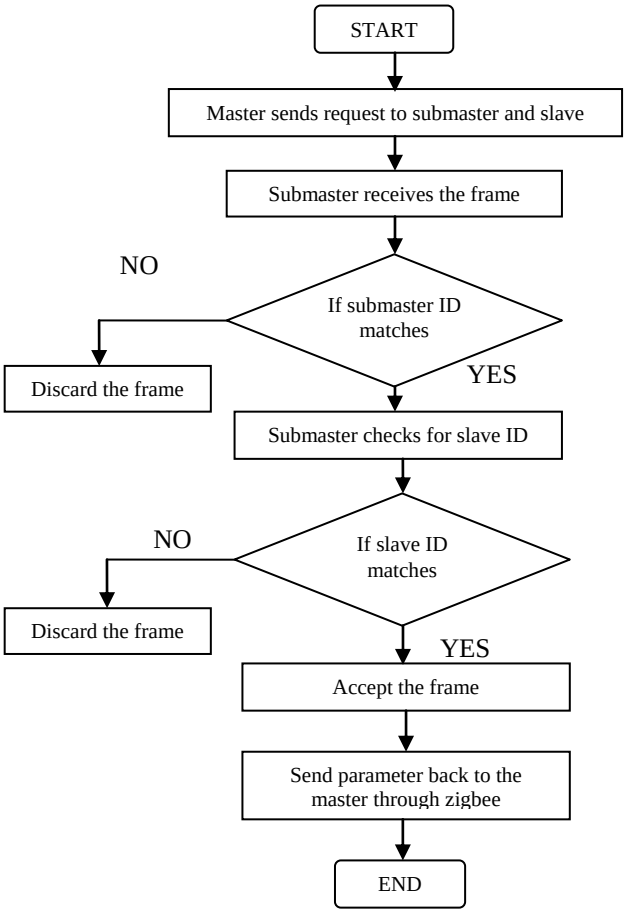

Figure3. Flowchart of Wireless Patient Monitoring

VI. CONCLUSION

The main objective of this paper is to design and implement a Master and slave communication using Zigbee based wireless patient monitoring using master slave combination. Thus the parameter such as pulse rate, triaxial accelerometer, ECG and body temperature which are measured directly from the human body displayed on LCD on the transmitter side which are connected to the slave. This data is transmitted to the master terminal PC i.e. hospital on the receiver side using Visual Basic software wirelessly through ZigBee. Here the cooperative communication also plays an important role to make sure that slave is always in the range of master. The PC master terminal is used to monitor the status of all the slaves which covers the whole area. Hence the transmission scheme ensures the successful transmission of these critical messages. It is fast and reliable.

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