Real time monitoring of ECG signal using PIC and web server

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Abstract:-This paper demonstrated the design of a wireless sensor network to monitor patients suffering from chronic diseases in their homes without regularly going to health center. Presently, most of the monitoring systems use personal computers (PC) to send patient's health data (ECG in this case) to the hospital from patient's home. Here, the idea is to eliminate the need of a PC thereby having a major cost reduction and still have a sustainable and effective system in place. The remote monitoring system consists of a WSN (wireless sensor network) in which nodes are placed in a patient's home. These nodes are connected to a central node which is installed at the hospital through an internet connection. The nodes of the WSN consists of ECG sensors, PIC microcontroller, CC2500 low power wireless radio. At first ECG signals are sampled by a portable device which is connected to patient to be monitored. The sampled signals are then transmitted wirelessly to an access point located in the patient's home through a CC2500 which works at a frequency of 2.4GHz. The access point is then connected to the internet through digital subscriber line router. Later, the data collected are sent to the hospital via internet for storage and further analysis. This remote monitoring can be advantageous in several ways. It can significantly reduce the cost of the entire setup by eliminating the need of a PC. There is a reduction in time to send the data as the need of turning the PC on every time has been diminished.

Keywords: ECG sensor, PIC16F877A, Zigbee, Internet

I. INTRODUCTION

In most of the instances, the cause for prolonged stay of patient in the hospital is not that the patient in reality needs proper medical attention. The reason for a patient to be hospitalised is for continuous monitoring especially in case of aged people. In recent years, hospital expenditures have increased dramatically. So, for those patients who need to be under observation shouldn't necessarily stay in the hospital and by doing so more space will be available for those who needs immediate medical care. So, for this several attempts have been made and the focus is on how to provide preventive care outside the hospital. Presently, there are some wireless monitoring setups (techniques) which have been designed. These mostly employ a PC or a mobile phone [1]-[3]. The ECG data are transmitted via internet but the main issue which all the existing system have in common is the cost of a PC, availability and the delay which occurs for turning on PC in order to transmit data and mostly aged people are not very comfortable using a PC especially if they are already under continuous care for a treatment.. Most of the existent methodologies carry the signals to the base station through an analog link causing the degradation of signal while transmitting [4]. The system described here can reduce the unnecessary stay in hospital for the sick patients who had to stay longer in hospitals owing to serious health issues but now they need only regular monitoring for knowing the after effects of medication.

This system presents a methodology where a group of sensor nodes placed near the heart will continuously monitor the parameters and signals are transmitted to the base station. For instance if a patient has earlier got a heart attack then he is likely to have another one. To avoid this, the person to be monitored has to put ECG measuring electrodes which will monitor the heart behaviour. Then, the analog signals are digitized and sent to the access point present in the home. This wireless access point is then connected to the hospital server which regularly monitors the ECG. On the hospital side, ECG viewer software generates the ECG graph which tells about patient's condition and if any irregularity is there then the doctor can take necessary steps by contacting the patient or send an ambulance to the patient's home. Gao [5] suggests a network made of sensors in urgent situation. The ECG signals are recorded and sent through 802.15.4 standard to a laptop for analysing. Fensli [6] suggested using a PDA to store ECG signals. Then, the recorded data will be transmitted to a remote location using GPRS. Jun [7] suggested to record the data from ECG detector and then transmit it to PC via Bluetooth. Khoor [8] suggested an online monitoring system but failed to provide the design aspects. Coosemans [9] suggested a monitoring system fitted in garment which can be extended up to a distance of 18cm. The suggested system provides benefits for those patients who wish to enjoy their normal routine life and for doctors who wish to distantly monitor their patients without unnecessarily staying in hospital and thus eliminating PC for data transfer from patient side to hospital side.

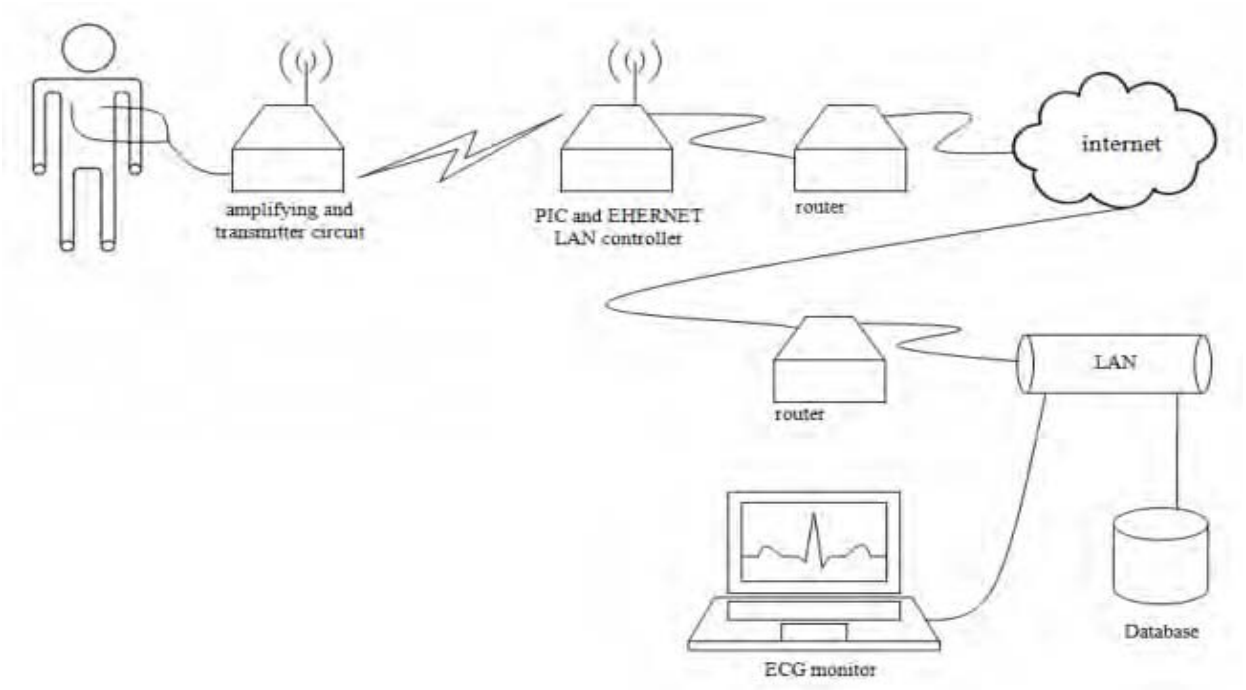

Fig 1: Overview of the monitoring system

II. SYSTEM MODEL

The overview of the monitoring system has been shown in fig 1. It consists of two different sections which are the patient side and the hospital side. At the patient's side, the ECG signals are captured, amplified, converted to digital from analog and then broken in to small wireless packets which are then transmitted wirelessly to an access point situated in home. The access point then merges all the small packets together and the merged packet is transmitted to hospital through internet. The hospital side receives signal and prepare the signal to be visualised by the medical practitioner and based upon which clinicians will take appropriate action.

A. Patient Home

The patient home consists of two modules which are Data acquisition unit and communication module for transmitting data between base station and hospital server. These two modules are discussed in detail below.

1) Data Acquisition Unit:

The three lead Ag/Agcl electrodes are attached to the patient's body and are used to convert the biological signal to electrical signal. The electrical signals acquired from electrodes are very weak and after processing the signal is digitized through ADC which is there in PIC microcontroller. The information regarding ECG mostly lies in the bandwidth ranging from 0.5 Hz to 35 Hz for monitoring applications and between 0.05 Hz to 150 Hz for diagnosis application. The ECG signals are very weak in nature ranging up to 2mV which causes baseline wander because electrode skin contact potential also ranges in the order of millivolts. The signal gets distorted from the noise of power line, muscle movement and breathing. Instrumentation amplifier AD620 was chosen to eliminate the noise from the ECG signal. This component was chosen because it has high common mode rejection (>100 dB), low input bias current (max. 1 nA) and low power consumption because maximum supply current is 1.3 mA. The acquisition system has PIC microcontroller which runs at 5V and which is supplied by the LDO voltage regulator. Due to this power supply, the ECG signal which are in the range of ±2 mV needs to be fitted as close as to the 0-5V range as possible. So, a total gain of 800 is needed. Now the unwanted frequencies should be filtered out and the signal should be amplified in such a way that the gain must be 800. It is attained using an antialiasing low pass filter. At this stage the ECG signal is ready to be digitized and which happens using the analog to digital converter of PIC microcontroller. Here the highest useful frequency is 150 Hz and a sampling rate of 300 Hz would be sufficient. The quantization resolution used here is 10 bits which is the maximum. resolution of PIC microcontroller. The overview of data acquisition unit is shown in fig 2.

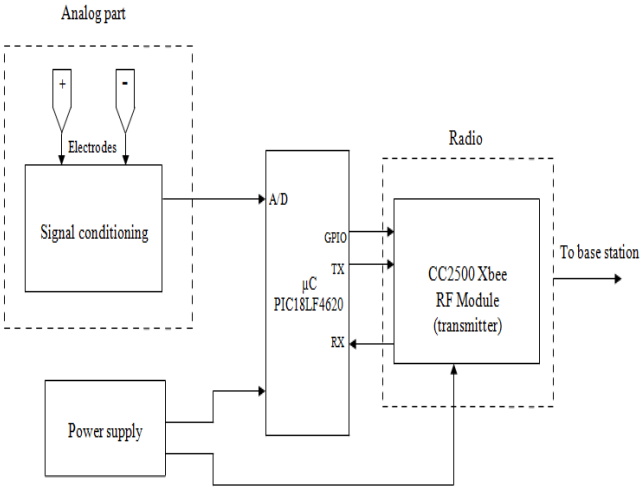

Fig 2: Overview of data acquisition unit

2) Communication Module:

The communication module has two parts, first is to transmit signal from data acquisition unit to base station, second is to receive the signals and then transmit it to the hospital server. For communication between data acquisition unit and base station CC2500 transceiver was used which communicated using PIC microcontroller. The CC2500 module operates at 2.4GHz and uses serial peripheral interface link to communicate with the controller. The microcontroller has 10 bit analog to digital converter for sampling the ECG signal. For communication between end device MPLAB IDE tool was used for writing code in C language. The code uses SPI interrupts and CC2500 primitives to communicate between the devices. Each network packet is of 101 bytes and the typical output is 54kbps which can handle 200 samples of 10 bits every second. This arrangement is used to send three packets in each duty cycle which equals to 2 seconds of recorded ECG data which takes 1.5 seconds to transmit the recorded ECG signal to the hospital server. The output from the receiving PIC is taken by RS232 cable and in order to transfer this signal through internet a serial to Ethernet converter is used. Then, finally end side collects ECG data and send it to the hospital server. The overview of communication module is shown in fig 3.

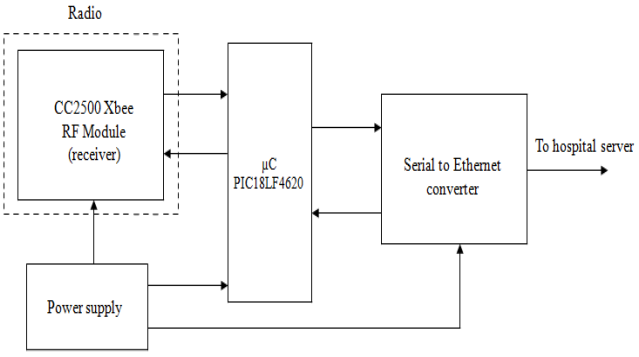

Fig 3: Overview of communication module

B. Hospital Side

The ECG signals from patient home are constantly transmitted to the hospital through internet. As it is transmitted in real time, the signal getting observed at patient side and being received at hospital side does not have any delay in transmission. Special software is designed which will collect and store up the ECG signal in database. The operating system used is windows server and the database for storing ECG data is SQL server. The order of communication between access point located at home and the hospital server is shown in Fig 4. The software flowchart for the collection of ECG samples and it's transmission is shown in Fig 5.The ECG monitoring software visualises the actual ECG signal on the computer hospital side. There are three main parts at hospital side which are ECG server, database for storing ECG and ECG visualisation software whose functions are discussed below:

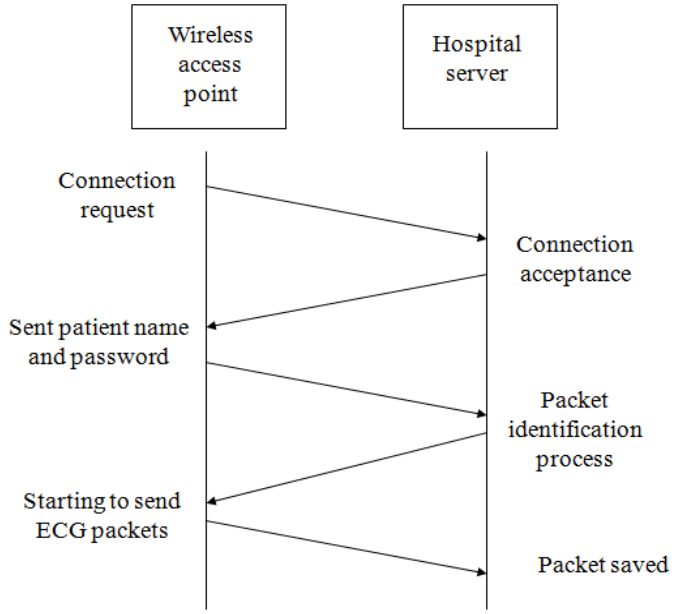

Fig 4: Sequence of communication

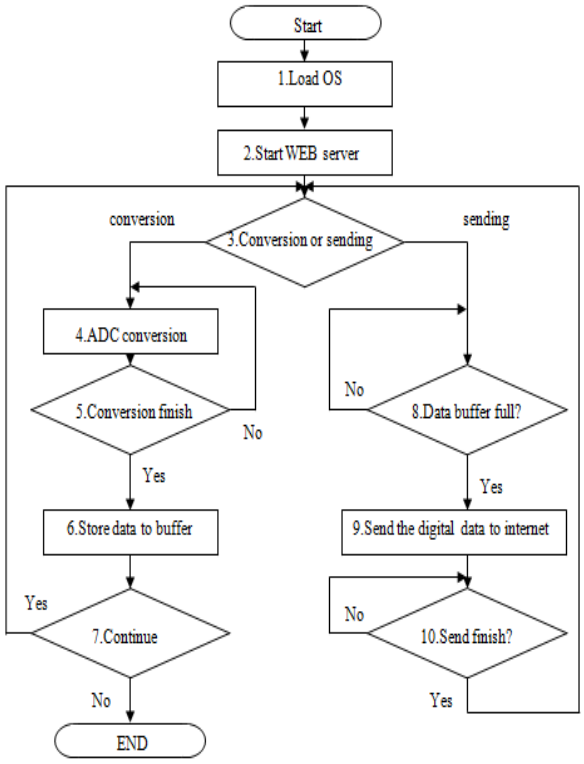

Fig.5 Flowchart for ECG data collecting and sending

1) ECG Receiving Server:

ECG signal receiving server software is intended to take delivery of signals from patient's home directly to hospital via an internet connection. The software designed is based on real time interaction between client and server application and is based on TCP/IP protocols. The ECG receiving server is implemented using Microsoft visual C++. The program used to trace ECG signals like an oscilloscope, reads data from the COM port at defined short interval then these traces are drawn on the screen using data received. The sole function of the ECG application software is to collect and save the ECG signal without losing the data packets. The other task is

to handle the TCP/IP connection and if any packets get lost then it's having reconnection management to take care of the lost connection.

2) Database For Storing ECG:

The configuration of ECG signals arranged in the SQL server is shown in Fig 6.In the shown figure, diagrams of the database having two tables are instanced. In the patient's table, all the personal information like patient name, patient ID, email address and mobile number is stored. The ECG signal table displays all the information regarding ECG with date and times are recorded. At any instant of time, the ECG record of the patient can be viewed by entering the patient details in the ECG signal table. Moreover, one ECG signal trace consists of 64 ECG samples.

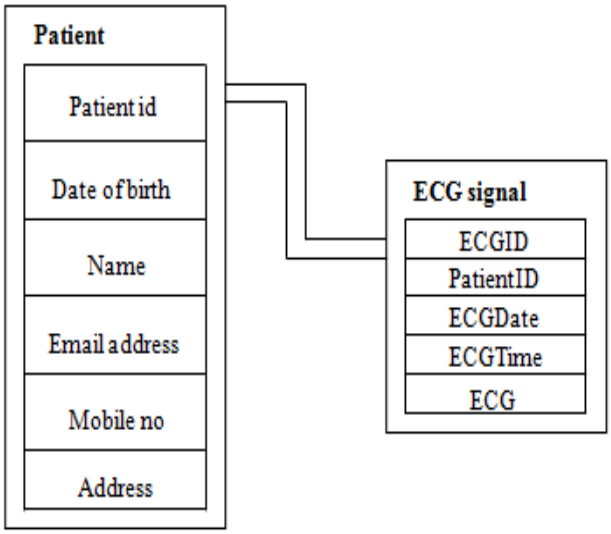

Fig 6: Configuration of ECG signals

3) ECG Visualisation Software:

For displaying ECG signal received through internet in a web environment, a ECG visualisation software is needed to ease access of information from the patient side. To display this, a web browser and internet is needed which should assure a secured and reliable access of the data and the information stored on the server. The ECG visualisation software is designed using JSP (Java Server Pages), and when a request is given to a web browser, it directly passes it to the JSP which processes the information and based on the information required by the user, it access the database either through JavaBean or to the JSP with the required information. The ECG visualisation software is used to examine and visualise the recorded ECG signals. Fig 7 shows a snapshot of the ECG viewing software. The practicality of this software is its ability to add, modify and delete the patient information. It plots the online ECG signal and when required can plot the saved ECG signal.

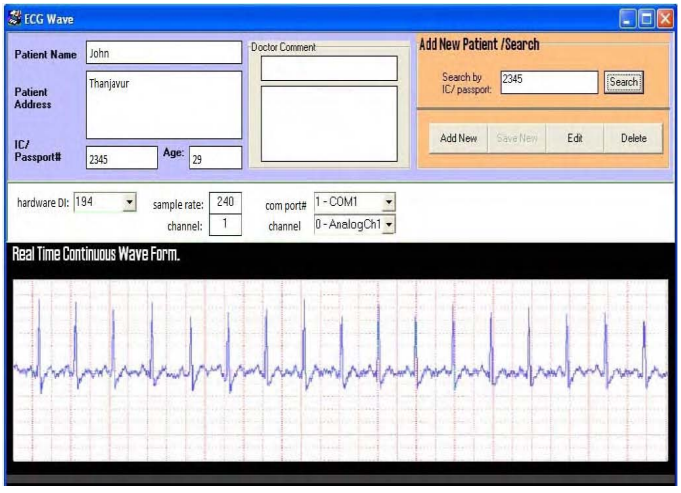

Fig 7: ECG visualised

III. HARDWARE SETUP AND OUTPUT

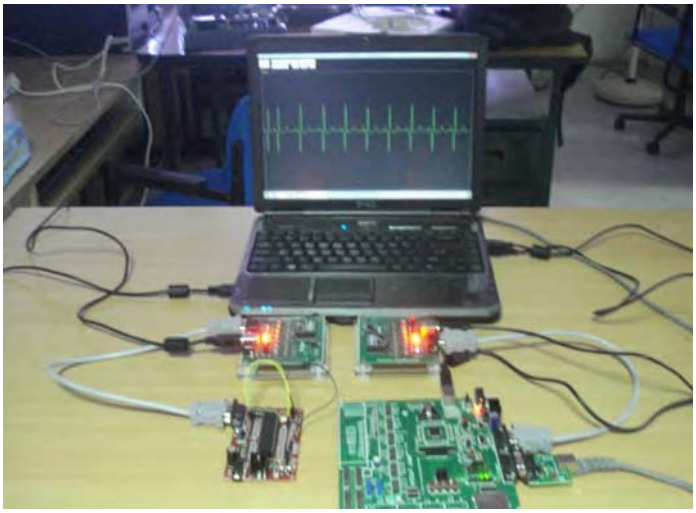

Fig 8. Hardware setup

Fig 9. ECG output

IV. CONCLUSION AND FUTURE ENHANCEMENTS

Today, medical practitioners and hospitals require a structured and dependable wireless observation system to monitor the real time ECG signals from patients who are staying outside hospital with maximum accuracy. The systems which are generally available for monitoring the ECG signals have limitations in transmitting the data which might be life saving. The developed system uses a wireless sensor network to observe the after effects of medicine on patient suffering from chronic heart diseases in their home with the help of remote monitoring system and it eradicates the dependency on PC. This system lowers the cost of monitoring patients and helps in monitoring physiological data required for normal functioning of heart. As a result of this proposed system, patients can enjoy quality medical care without visiting a hospital. This also reduces the unnecessary stay of the patient in the hospital and indirectly saving their quality time and precious money. For future work, the setup can be extended to monitor multiple sensors for other biological signals like body temperature, blood pressure, body movement, content of oxygen in the blood etc. It would also be modified and made capable of monitoring several patients simultaneously.

ACKNOWLEDGEMENT

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