Real Time Multi-Patient Heart Rate and ECG Monitoring System Using Wireless Sensor Network

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Abstract – *On one side world's population is growing as well as aging rate is also increasing dramatically. This aging of population causing many painful diseases because of unhealthy lifestyle. Heart diseases are on the top in that list. Electrocardiogram (ECG) shows the working of heart. To monitor heart condition as well as heart rate from the remote location will be preferable for both patient and doctor. Here we propose a real time multi-patient heart rate and ECG monitoring system using wireless sensor network which can be applicable for hospitals having many number of patients to be monitored as well as the patients who can be monitored from home also. This prototype proposes ECG and heart rate monitoring system at low cost.*

*Key Words***: Multi-Patient, Wireless Sensor Network, Cardiac Monitoring, Zig bee.**

1. INTRODUCTION

Population aging is the big problem in today's era. Population aging means shift in the distribution of a country's population towards older ages.Aging of population causes expenses on medical issues. Today's lifestyle is also a big reason behind it. Weight gain, poor diet, unhealthy junk and low nutritious food is not at all good for health. Busy lifestyle can impact your physical as well as mental health. These things last into depression and stress. All these things directly affects your heart as well as these things increase your medical expenses.

Cardiovascular (or heart) diseases can be detected with cardiac monitoring. Cardiac monitoring can be of two types-1) External Cardiac Monitoring 2) Implementable and insertable cardiac monitoring. External cardiac monitoring is a traditional type of monitoring where the electrodes are located on patient's body for between 24 hrs to 30 days. Devices monitor as well as store data. These monitoring devices can be connected to mobile devices. So experts can review that and can conclude about disease. Insertable and implementable cardiac monitoring is related with the electrodes are placed just under the skin. Patient can continue with regular activities once the wound has healed. This type of monitoring is required when patient needs long term of monitoring up to three years.

Cardiac monitoring includes heart rhythm disorders also called cardiac arrhythmias. Heart beat is the result of electrical activities in heart while pumping of the blood. If there is malfunction in hearts activity then heart beats can be irregular, too slow or too fast. Sometimes irregular heart rate is not so serious, it may happen due to simple changes in lifestyle. But sometimes if patient feels recurrent fainting or unexplained strokes or artrial fibrillation- arrhythmias can be dangerous as well as potentially life threatening. In such cases continuous monitoring of heart activity is required because the predictions based on short term monitoring may fails.

Cardiac monitoring at hospital is not possible in each case of patient because of cost as well as it is not possible for doctors also to allow large numbers of patients in the hospital for long time just for the observation purpose. On the other hand cardiovascular disease is responsible for an estimated 16.7 million deaths worldwide (30% of all deaths)[1].Another important aspect is of expenses on the solution of this problem should be less.

Many devices and solution for heart monitoring have been proposed in the market.[2-5]They typically consist of monitoring, data logging and visualization of ECG with web or Smartphone with wireless devices. ECG signal filtration and processing requires a complicated as well as bulky circuit. As well as it requires more power to send data wirelessly. Due to bulkiness circuit cannot be portable or handy. With all these cost is the key issue. These devices should be at low cost.

For all these reasons here we propose a real time multi patient heart rate and ECG monitoring system which is dedicated for the indoor environment of hospital as well as cardiologist can monitor patients if they are at home without any assistance. So the non-technical user can also handle it. This system has following benefits over existing systems as follows-

1.1Reduction in electrodes

Typical ECG acquisition system is having minimum twelve electrodes attached on body. It is irritating to wear all these electrodes on body for long time. The system we propose, is having monitoring or analysis based on three electrodes. So it will be comfortable for user to wear it for

a long time. Another benefit is that a non technical user can also use it easily.

1.2 Mobility and monitoring from remote location,

wireless Networks allows facility to user or patient of hospitalization at home. As well as clinician can use it in hospital to monitor multiple patients at a same time on the web page from remote location.
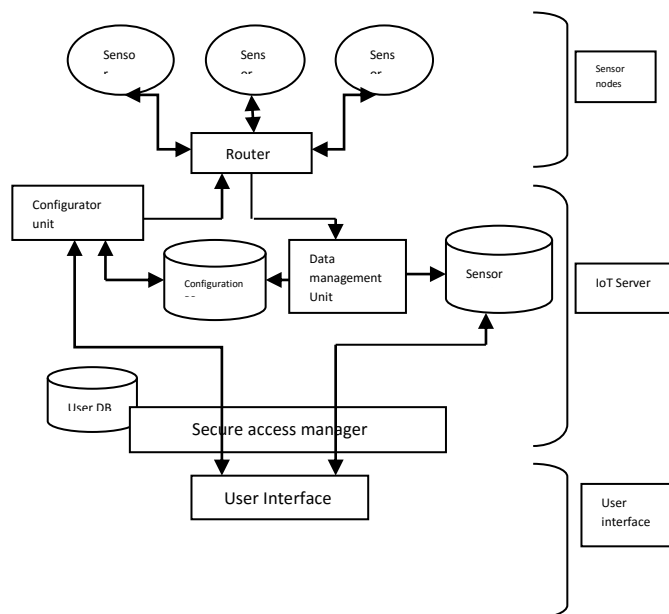
2. SYSTEM OVERVIEW

Fig-1: System Architecture

The architecture of proposed system is as shown in Fig 1. Here we shall give briefly illustrate about the system. The system is having three subparts: Sensor nodes, IoT server and user interface.

2.1 Sensor Nodes

ECG acquisition and processing circuit is connected to patient as it is three electrodes based processing. Any type of controller is required here to control the data coming from ECG processing circuit. This architecture can be used for different network protocol(like zigbee, Bluetooth,wifi,etc).For wireless communication with the main server, any type of wireless device should be connected here. Electrodes attached to body on right places will acquire signal. Further this signal goes to the signal processing unit. Here it filters, removes dc components, boosts signal and it send to the controller connected to it. As the signal is analog, it is preferable to convert it into digital. That part will be done by the controller. Wireless module is connected to the controller

to send the signal wirelessly. For this proto type we are assuming two sensor nodes.

2.2 IoT Server

Data from the sensor nodes comes here through wireless medium. On the server it will be stored into database. In database, sensor database as well as user database is also there. Sensor database stores the information about sensor output i.e. ECG information. User database is created for security purpose. Only authorized person can see the information, so the security is provided. On personal computer another zigbee is connected. It receives data from multiple transmitters and stores into a tables created for different patients. A common database can be used.

2.3 User Interface

Information about particular patient will be provided for authorized person through web page or on the mobile device. On the web page authorized person can monitor the ECG graph as well as can keep watch on the heart rate and extra analysis can be added based upon sensor database information This data can be used here by the clinician to predict the conclusion about the condition of heart. For that a web page is created on which you can see the information about the patient as well as heart rate and ECG waveform and analysis on the waveform stored in the database.

3. ECG SENSOR AND IMPLEMENTATION

Fig-2: ECG sensor module and electrodes

AD8232 is integrated signal conditional block and specially used for biomedical applications. It extracts small bio potential signal, amplifies and filters it in presence of noise conditions such as those created by movement or remote electrode placement.AD8232 consists of a two pole high –pass filter to eliminate motion artifacts and electrode half cell potential. The filter is tightly coupled with instrumentation amplifier to allow both large gain and high pass filtering in a single stage, which saves space and cost.

AD8232 is having the operational amplifier which creates three –pole low pass filter to remove additional noise. To

improve common mode rejection of the line frequencies amplifier is used for driven lead applications, such as right leg drive(RLD).AD8232 is having fast restore function. When there is abrupt change in signal this module automatically adjusts to a higher filter cutoff.AD8232 can work on 2.0 to 3.5V ,low supply current 170uA.It is having high signal gain(G=100)and size is 20 lead 4 mm x 4 mm LFCSP package.
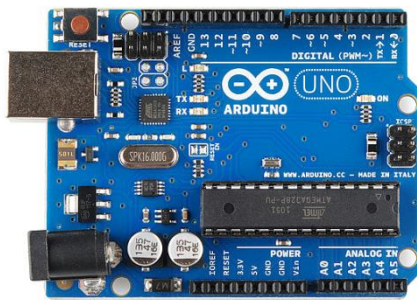
3.1 Arduino

Fig -3: Arduino Uno

In this proto type we have used arduino as a controller for zigbee and sensor module. It is based on ATmega 328.It is an open source , prototyping protocol. Following are the features-input voltage range is 7-12V, 14 digital I/O pins,32KB flash memory, SRAM of 2 KB,EEPROM of 1 KB and clock speed of 16 MHz. Aruino is suitable for this application.

3.2 Zigbee

Zigbee is used to transmit data wirelessly. Following table gives the comparison between other protocols with zigbee.

	ZigBee	802.11 (Wi-Fi)	Bluetooth	UWB (Ultra Wide Band)	Wireless USB	IR Wireless
Data Rate	20, 40, and 250 Kbps	11 & 54 Mbps	1 Mbps	**100-500 Mbps**	62.5 Kbps	20-40 Kbps 115 Kbps 4 & 16 Mbps
Range	10-100 m	50-100 m	10 m	<10m	10 m	<10 m
Networking Topology	Ad-hoc, peer to peer, star or mesh	Point to hub	Ad-hoc, small networks	Point to point	Point to point	Point to point
Operating Frequency	868 MHz(EU) 900-928 MHz (NA), 2.4 GHz (Global)	2.4 and 5 GHz	2.4 GHz	3.1-10.6 GHz	2.4 GHz	800-900 nm
Complexity	Low	High	High	Medium	Low	Low
Power Consumption	Very low (design goal)	High	Medium	Low	Low	Low
Security	128 AES + application layer security	-	64 and 128 bit encryption	-	-	-
A Device joins network in..	Under 30ms	3-5 secs	Up to 10 secs	-	-	-

Fig-4: comparison of various protocols with zigbee

In multi-patient scenario two zigbee modules will work as transmitter while one zigbee will receive data to avoid congestion problem or to control the traffic delay of each transmitting zigbee should be adjusted or each zigbee should follow wake up and cyclic sleep schedule. So the collision of data at the transmitter can be avoided. In zigbee configuration two modes can be used AT and API. To avoid the collision API mode can be used which will send data in the form of packets.

3.3 User Interface

To provide patient information as well as graph on the webpage, it requires a database server. This prototype is based on XAMPP server which gives MySQL database to store received data from zigbee. In the particular database two separate tables are there for each patient information. Data coming from zigbee is having prefix which shows data coming from different users/patients. Data is separated at COM port python script and then it stores into appropriate table. Then web page is based on PHP ,HTML code which fetches data from database and display it on web page. For security purpose user database is created so only authorized person can access that web page.
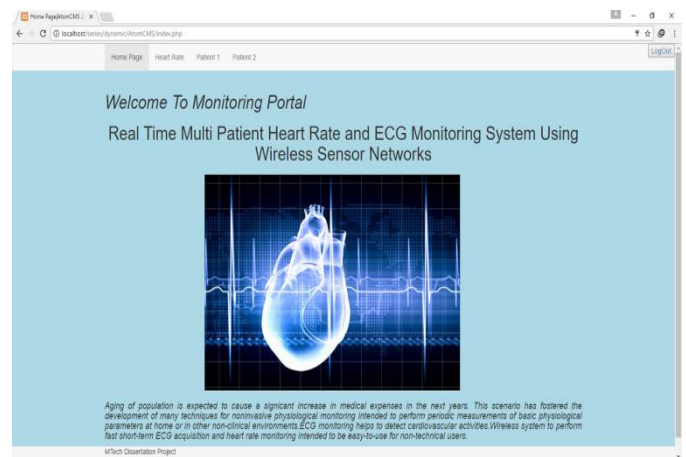

Fig-5:Monitoring Web Page

3.4.Heart Rate Calculation

On sensor side we detected a peak of the waveform i.e QRS interval on the serial plotter of the arduino.Heart rate can be calculated on sensor database.There are many ways to calculate heart rate It set as threshold for the heart rate calculation.Timer starts when first peak is detected and stops when next peak detects.Now the heart rate is calculated as follows:

Heart Rate = 1/T beats per minute
Where T = time between two successive peaks

3.5.Experimental Results

We have experimented for this prototype.Here three electrodes are placed as one on right arm,one on left arm and remaining on right leg.The output of the AD8232 on digital oscilloscope is as below:

Fig-6:ECG Output of AD8232

This Output is in analog form.It is connected to the arduino uno which receives and converts it into digital. The waveform obtained on the serial monitor of Arduino Uno is as shown below:
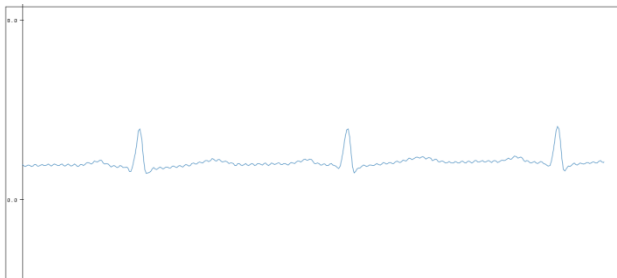

Fig-7:ECG Output On the serial Monitor of Arduino Uno

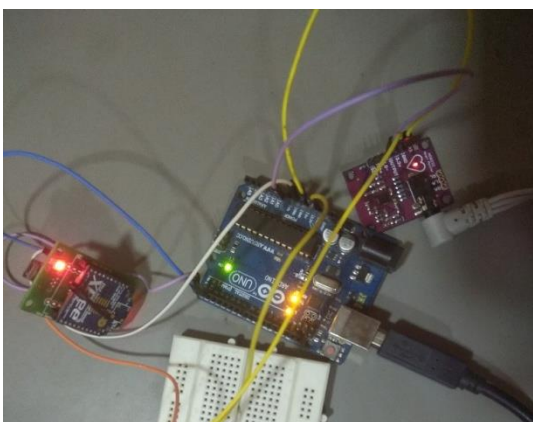Experimental Setup used for this is as shown below:

Fig-8: Experimental Setup On Sender side

Same is about another patient.Two patients are considered here for the prototype.On monitoring portal heart rate is calculated for each patient.The results of our first patient are:
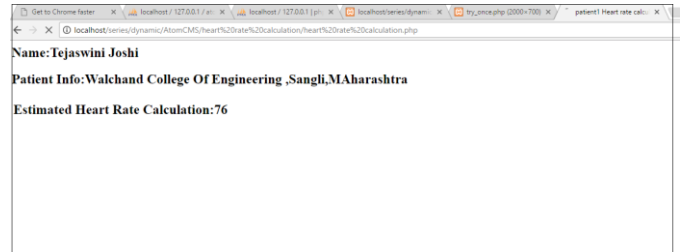

Fig-9: Monitoring portal page

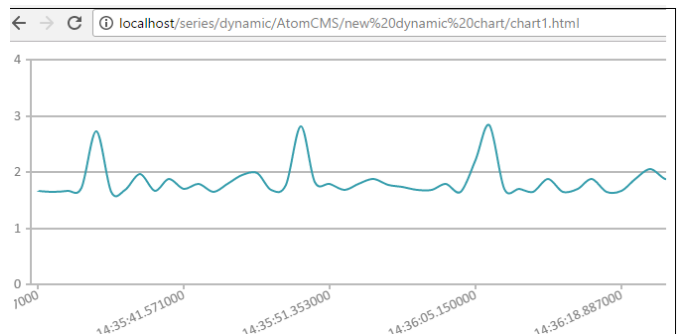Waveform also can be displayed here from the database values received by receiver.

Fig-10: Waveform On website

As the security is provided,only autorized person can see this information.

4.ANALYSIS OF HEART RATE

Heart rate is a familiar clinical variable for heart disease prediction.Based on heart rate monitoring for long time,analysis can be done on the basis of following:Resting Heart Rate(RHR) is one of the simplest cardio –vascular parameter.RHR usually avaerages 60 to 80 beats per minute (b.p.m).It occasionally exceeds 100 b.p.m.Also it can be as low as 30 b.p.m. in highly trained atheletes.[6]According to patient's age heart rate can be calculated as take 220 and subtract patients age.that will be the maximum physiological limit of heart rate for patient.Most exercise program suggest that your heart rate should not exceed 60-70% of the maximum heart rate during exercise.[7]Changing heart rate is not an issue for concern.But while monitoring continuously decreasing or high heart rate may be dangerous for health. Patients with the highest heart rates (≥87 bpm) had a more than 2-fold higher risk for the primary composite end point (cardiovascular death or first hospital admission for worsening heart failure) than patients with the lowest

heart rates (70 to <72 bpm; HR, 2.34; 95% CI, 1.84-2.98; P<0.0001). The risk of these end-point events increased by 3% with every bpm increase from baseline heart rate and by 16% for every 5-bpm increase[8].

To check the efficiency of the system we applied electrodes on two patients(as we are implementing system for multiple) and continuously monitored their heart rate as well as waveform as per the condition of heart for one hour. Range of the heart rate was from 72 b.p.m. to 80 b.p.m. for patient 1 and from 80 to 92 for patient 2.We experimented the same after exercise or while doing exercise. It shows a difference in heart rate when patient is resting and he is doing some exercise. Later we compared these results with a well-practiced physician. Results were approximately same as they were in normal range and if any abnormalities occur, system gave warning. In this experiment while doing exercise heart rate changes continuously. Sometimes suddenly it exceeded above or below normal range. Though it was not serious in this case, still system gives warning on a web page so the patient or user should get analysis as well as alert.

5. CONCLUSION

The proposed real time heart rate monitoring system for multiple patients is based on wireless sensor network. The use of zigbee as wireless protocol reduces power consumption and hence results in increase of battery life. This system allows monitoring of more number of patients at home or hospital. Due to smaller size of system, it is portable. The system is simple to handle and does not involve complexity, so a layman also can operate the system.

The further additions to system can be made as follows: a router can be replaced by gateway which will be suitable for any kind of protocol on sender side, additional analysis of ECG waveform to provide idea of risk of probable heart disease can be added. Also for the patient at home, immediate emergency alert about if any irregularity occurring frequently, can be sent through message (SMS) or phone call to clinician or responsible person. Hence the life of patient can be saved

REFERENCES

[1] Jean-Eric Tarride,Morgan Lim,Marie DesMeules,Wei Luo,Natasha Burke,Daria O'Reilly,James Bowen,Ron Goeree "A review of the cost of cardiovascular disease," Can J Cardiol, vol. 25(6), Jun. 2009, pp. e195-e202.

[2] Elisa Spano,Student Member,IEEE ,Stefano Di Pascoli,and Giuseppe Iannaccone,Senior Member,IEEE, " Low Pwer Wearable ECG Monitoring System For Multiple-Patient Remote Monitoring",IEEE SENSOR JOURNAL,VOL.16,NO.13,JULY 1,2016

Joan Gomez-Clapers and Ramon Casanella,Member IEEE, "A Fast And Easy-To-Use ECG Acquisition and Heart Rate Monitoring System Using a Wireless Steering Wheel",IEEE SENSOR JOURNAL,VOL.12,NO.3,MARCH 2012

[3] Shuenn-Yuh Lee, Member, IEEE, Jia-Hua Hong, Cheng-Han Hsieh, Ming-Chun Liang, Shih-Yu Chang Chien, and Kuang-Hao Lin, Member, IEEE, "Low-Power Wireless ECG Acquisition and Classification System for Body Sensor Networks",IEEE JOURNAL OF BIOMEDICAL AND HEALTH INFORMATICS, VOL. 19, NO. 1, JANUARY 2015

[4] Kasim M. Al-Aubidy, Ahmad M. Derbas. & Abdullah W. Al-Mutairi,Intelligent & Embedded Systems Research Group,Faculty of Engineering, Philadelphia University, Jordan, "Real-Time Patient Health monitoring and Alarming Using Wireless-Sensor-Network",2016 13th International Multi-Conference On Systems,Signal & Devices

[5] Stephane Cook,Mario Togni,Marcus C. Schaub,Peter Wenaweser,Otto M. Hess, "High heart rate:a cardiovascular risk factor?",European Heart Journal(2006) 27,2387-2393

[6] www.nemahealth.org/index.php/heart-rate-or-pulse-2

[7] Martin R Cowie, "Heart rate as a treatable risk factor in cardiovascular disease",Medicographia,A servier publication,Vol 34,No.4,2012