Patient Monitoring using GSM and Zigbee and Data Logging System

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ABSTRACT
In hospitals, considering the huge campus, it is very difficult for the doctors to reach every patient for their daily updates and its very time consuming to monitor all the patients on daily basis. Home care services are growing up in the past years. Contemplating the patient-family pair, it represents a solution to the medical problems of the modern life. Also in critical situations, it is very important to report the live health status of the patient to the doctor and provide immediate medical help to the patient during the critical hour. Statistics reveal that everyday many lives are affected because the patients did not get timely and proper help. This paper shows design and development of a reliable, energy efficient patient monitoring system. It is able to send parameters of patient in real time. It enables the doctors to monitor patient's health parameters (temperature, heartbeat etc.) in real time. The paper presents the design and implementation of a Remote Patient Monitoring (RPM) system based on wireless technology using a cellular phone, to send an SMS (Short Message Service) to the medical staff. The proposed system combines two commonly used technologies namely, Global System for Mobile (GSM) and ZigBee Technology

General Terms
Remotely accessing patient's health using ZigBee and GSM and saving patient's health statics in the form of data logs.

Keywords
Patient Monitoring, ZigBee, GSM, Data Logging Syatem, Remotely access patient's health.

1. INTRODUCTION
So for such scenarios this paper has proposed a system which is wireless and it will give all the information about the patient's vitals to the doctor at one central station of hospital where they can monitor the patient. This will contain a .Net based software interface, which will also log the data of the patient's vitals so that it can be analyzed to determine the patients' health situation. And this interface will also contain the Medicines that have been recommended by the doctors, so that the staff other than the doctor can take care of the patient in absence of the doctor. Ambulatory patients are well suited to be monitored using wearable sensors. The goal of such systems is to provide early warning of physiological deterioration such that preventative clinical action may be taken to improve patient health.

Despite wearable patient monitors now being manufactured commercially, allowing the collection of continuous physiological data from ambulatory patients, the resulting quantity of data acquired each day is large, and a "data deluge" effect occurs. The workload of clinicians and healthcare workers prevents them from inspecting long time series of multivariate patient physiological data to a high degree of accuracy, and the predictive aspect to patient monitoring is lost. Therefore online processing of these large datasets is, therefore, required for predictive monitoring.

However, existing clinically validated devices often simply compare physiological data to data determined by trial-and-error, variable thresholds and generate an alert if those thresholds are exceeded.

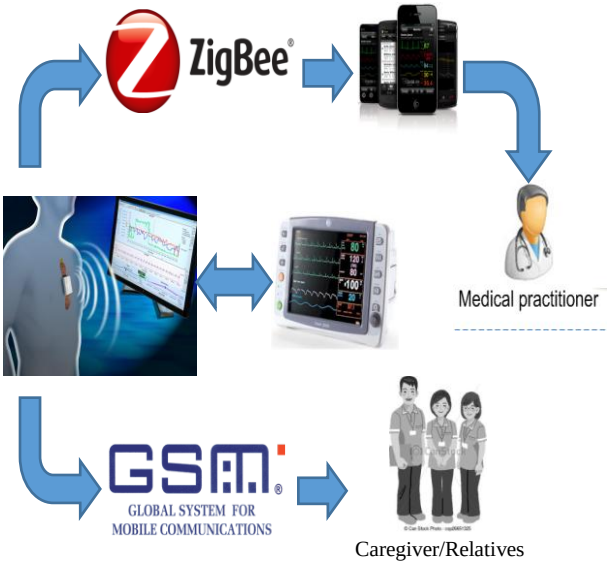
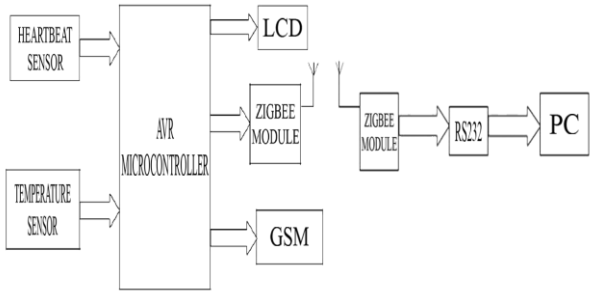


Figure 1. Basic Working Of Patient Monitoring.

2. LITERATURE SURVEY
Few years ago a person's heartbeat was generally measured personally by connecting patch cord on their chest. This created a problem to keep a tab on patient's health and provide treatment in case of emergency. Lately, measurement of Heartbeat and Temperature is done with the help of stethoscope and thermometer which require personal visit.
To overcome these limitations the paper has proposed a system to enable remote access of statistical representation of any patient's biological parameters. Here the ZigBee is used for the hospital communication for monitoring the patient.

3. DESIGN METHODOLOGY
This paper shows measuring patient vitals using Heartbeat sensor and Temperature sensor which indicates one of the critical vital states of patient. The data received by the sensors will be processed by the predefined software and will be transmitted to the transmitter side of the ZigBee module which will be near to the patient's room. This data will be received at the receiver side of the ZigBee module which will be at the doctor's desk. At the same time, in case of any critical condition, there is a GSM module which will send an alert message to all the numbers that are predefined in the

program. The critical condition will be decided based on the readings received from the Temperature sensor and the Heartbeat sensor. The alerts generated from the sensors transmitted with the help of GSM will help providing proper treatments to patients within the "Golden Hour".
Following is a block representation of the working of the system.



TRANSMITTER (At Patient Side) **RECEIVER (At Hospital Control Room Side)**

Figure 2. Block Representation of the System

These vitals are going to be measured using dedicated sensor such as heart beat sensor and temperature sensor, this sensors are interfaced with AVR µC which will take these parameters and it will forward these values to central PC using ZigBee and check the values for any critical situation if it falls under any life threatening situation then it will send message to the doctors by using GSM module.
So the following components are to be used in this project

1. AVR µC 128
2. Heart Beat sensor(KYT04509V1.1)
3. Temperature sensor(MLX90614)
4. GSM SIM 900 module
5. ZigBee
6. PC side we will have .NET interface

1) **AVR Microcontroller 128**: It collects output of the sensors and analyses it. Then sends it to the doctor's pc through ZigBee transmitter and to the doctor's mobile through GSM module. The high-performance, low-power Atmel 8-bit AVR RISC-based microcontroller combines 128KB of programmable flash memory, 4KB SRAM, a 4KB EEPROM, an 8-channel 10-bit A/D converter, and a JTAG interface for on-chip debugging. The device supports throughput of 16 MIPS at 16 MHz and operates between 4.5-5.5 volts. By executing instructions in a single clock cycle, the device achieves throughputs approaching 1 MIPS per MHz, balancing power consumption and processing speed.

2) **ZigBee Module**:
Sensors value should be sent to the central machine of the hospital which can be achieved by using ZigBee. It consists of a transmitter and a receiver for communicating data from microcontroller to the doctor's pc.

3) **Heart Beat Sensor**:
Heart Beat sensor is designed to give digital output of Heart beat when a finger is placed inside it. This digital output can be connected to microcontroller directly to measure the Beats per Minute (BPM) rate. It works on the principle of light modulation by blood flow through finger each pulse. Its dual low power operational amplifier consists of a super bright red LED and light detector. One will act as amplifiers and another will be used as comparator. LED needs to be super bright as the light must pass through finger and detected at other end. When heart pumps a pulse of blood through blood vessels, finger becomes slightly more opaque so less light reach at the detector. With each heart pulse, the detector signal varies which is converted to electrical pulse.

4) **Temperature Sensor**:

Temperature sensor will be interfaced with AVR using ADC (Analog to Digital convertor), the value which is sensed by the temperature sensor is in Analog form which is not understandable by the µC which has to be digitize by the ADC which then in digital format to do further calculation and for our algorithm. So now these values will be transmitted using GSM and ZigBee

5) **GSM**:
In this µC, the people to whom we desired to share our critical situation will be predefined. So the algorithm will first check for any critical situation from the values, and if found, than the Embedded system will generate the message for the desired persons and this alert message will be sent.

6) **Software side for Database**:
The wirelessly data sent by the Embedded system will be received by the PC which will be presented in Graphical interface which will be developed by .NET. It will receive the data and it will display the data LIVE. It will also store the data in Historical format for further analysis.
An illustration of the above hardware is as shown in the flowchart below.

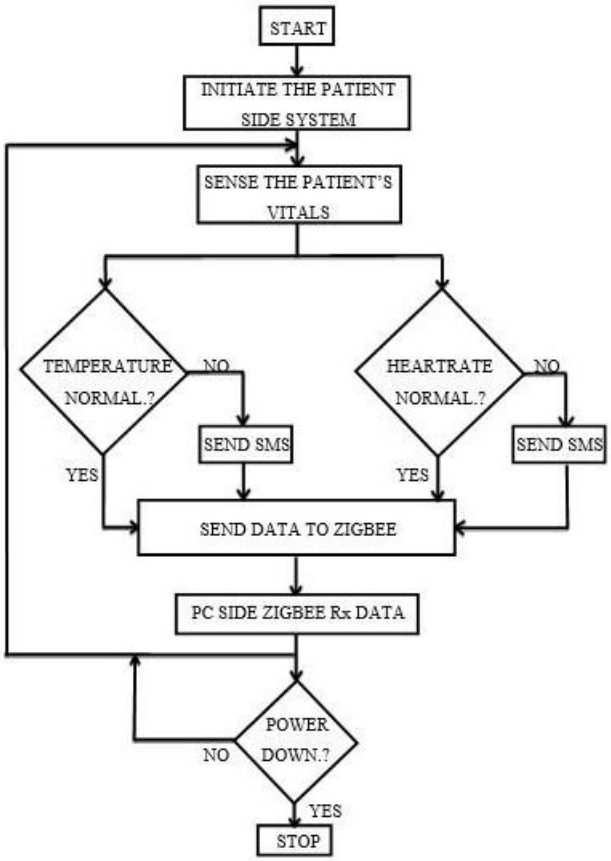


Figure 3. Flowchart representing the entire operation

Alert System:- The system will have predefined levels for the sensor, which will define the critical level for the patient, if this vitals drop below the abnormal then the SMS will generate by the system and will be sent to the Doctor and the patient family.

Data Logging Process: - The Temperature sensor and Heart beat sensor will monitor the patient as per there vital and give

the information to the µC. µC will take this value and it will transmit this value on it ZigBee network where the central system will receive this data.

Now at the PC side it has the ZigBee which will receive the data which is sent by the Patient side system. This software will receive the data and it will generate the Daily Log of the data as per the time it has been received. The Doctor can also access the old data as per the Date, so that doctor can analyze the patient health status.

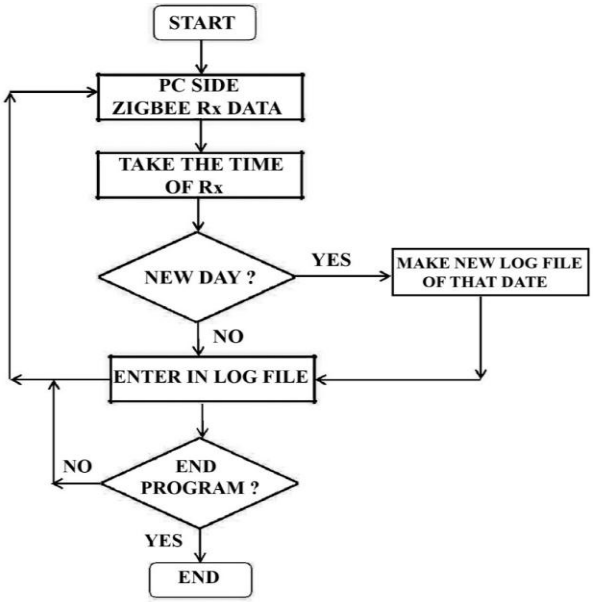


Figure 4. Flowchart for the database updating

4. TOOLS TO BE USED

1) Avr Microcontroller 128

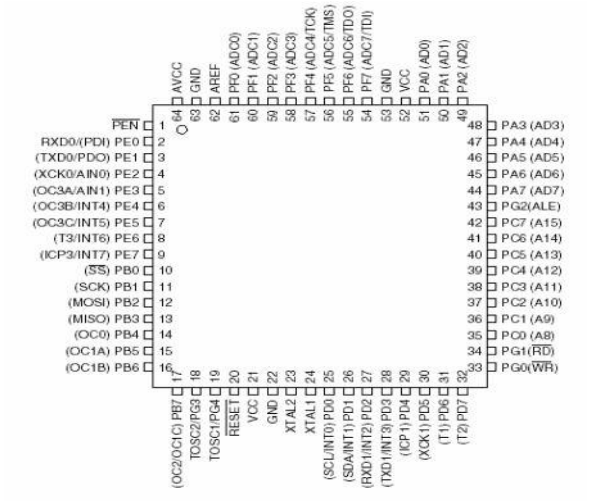


Figure 5. Pin Diagram of AVR 128

VCC Digital supply voltage.

GND Ground.

Port A to F Ports are an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). As inputs, Port pins that are externally pulled low will source current if the pull-up resistors are activated. The Port pins are tri-stated when a reset condition becomes active, even if the clock is not running.

Port G (PG4--PG0) Port G is a 5-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port G output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port G pins that are externally pulled low will source current if the pull-up resistors are activated. The Port G pins are tri-stated when a reset condition becomes active, even if the clock is not running. The port G pins are tri-stated when a reset condition becomes active, even if the clock is not running.

RESET Reset input. A low level on this pin for longer than the minimum pulse length will generate a reset, even if the clock is not running. Shorter pulses are not guaranteed to generate a reset.

XTAL1 Input to the inverting Oscillator amplifier and input to the internal clock operating circuit.

XTAL2 Output from the inverting Oscillator amplifier.

AVCC AVCC is the supply voltage pin for Port F and the A/D Converter. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter.

AREF AREF is the analog reference pin for the A/D Converter.

PEN PEN is a programming enable pin for the SPI Serial Programming mode, and is internally pulled high. By holding this pin low during a Power-on Reset, the device will enter the SPI Serial Programming mode. PEN has no function during normal operation.

2) Power supply

The 12V AC supply to the step down transformer, in power supply unit, converts AC to DC using bridge rectifier.

3) ZigBee Transmitter and Receiver

ZigBee wireless network technology is launched and made by ZigBee Alliance, founded in August 2001, is a fast-growing organization. It mainly focuses on reliability, simplicity, low power and low cost. The ZigBee module is used to transfer information from the patient section to the server section. With ZigBee, communication upto about 50-100m away becomes easy.

There will be a ZigBee at the transmitting end for transfer of information and a receiving ZigBee at the receiving end for receiving the transmitted information and finally the received data is sent to the PC. At the PC a coding is written using Visual basic for transmitting the information of any abnormal health conditions to the specified mobile number in the program through a GSM modem.

Figure 6. ZigBee Transceiver

Features/Benefits

- 2.4 GHz for worldwide deployment
- Fully inter-operable with other Digi Drop-in Networking products, including gateways, device adapters and extenders
- Multiple antenna options
- Industrial temperature rating (-40° C to 85° C)

4) Mobile and GSM SIM 900 module

GSM (Global System for Mobile Communications) is a global digital mobile communication system, whose coverage is the most widely and reliability is very high. A GSM modem is a wireless modem that works with a GSM wireless network. The main difference between them is that a dial-up modem sends and receives data through a fixed telephone line while a wireless modem sends and receives data through radio waves.

Figure 7. GSM Modem

5) Heart Beat Sensor

This sensor monitors the flow of blood through a clip that can be used on a fingertip or on the skin between the thumb and index finger. At rest, an adult man has an average pulse of 72 per minute. Often it is more convenient to use a program that simply displays the pulse rate in beats per minute. The amount of the blood in the finger changes with respect to time.

The sensor shines a light lobe (a small very bright LED) through the ear and measures the light that gets transmitted to the Light Dependent Resistor. The amplified signal gets inverted and filtered, in the Circuit.

Features of Heartbeat Sensor

- Provides a direct output digital signal for connecting to a microcontroller
- Works with a working Voltage of +5V DC
- Works as a Digital Heart Rate monitor
- Used as a Bio-Feedback control of robotic applications

Working of a Heartbeat Sensor

The heart beat sensor circuit diagram comprises a light detector and a bright red LED. The LED needs to be of super bright intensity.

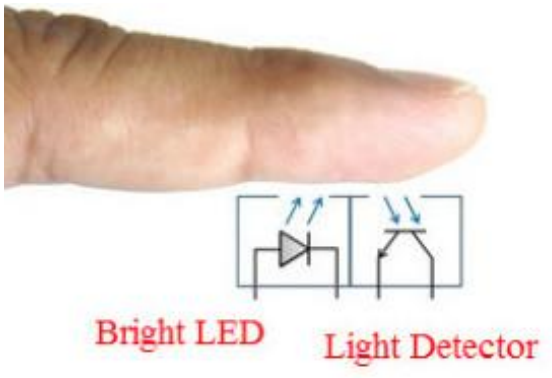


Figure 8.Heartbeat Sensor Principle

Now, when the heart pumps blood through the blood vessels, the finger becomes slightly more opaque; due to this, less amount of light reaches from the LED to the detector. With every heart pulse generated, the detector signal gets varied. The varied detector signal is converted into an electrical pulse. This electrical signal gets amplified and triggered through an amplifier which gives an output of +5V logic level signal.

6) Temperature sensor (MLX 90614):-

The temperature sensors can measure temperature signals which are sent to the microcontroller. The data is then transmitted by ZigBee to the PC. The sensors are connected to the I/O port of the microcontroller. It is electronic device which provides a voltage analog of the temperature of the surface on which it is mounted.

Figure 9. Temperature sensor (MLX 90614)

PIN DESCRIPTION

Table 1. Pin Description

NAME	FUNCTION
SCL	Serial CLock
SDA	Serial DAta

Features:

- Small size, low cost
- Factory calibrated in wide temperature range: -40 to 125 °C for sensor temperature and -70 to 380 °C for object temperature.
- Measurement resolution of 0.02°C
- SMBus compatible digital interface

- Movement detection;

Applications include thermostatic controls, industrial systems, consumer products, thermometers, or any thermally sensitive system, HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.

7) PC: -
To monitor Patients health via ZigBee Receiver. The data transmitted by the ZigBee transmitter is received by the ZigBee receiver situated at the doctor's place. The data received is displayed on the PC to make it easier for the doctor to read.

8) Visual Basic .NET
Microsoft launched VB.NET in 2002. Microsoft's integrated development environment (IDE) for developing in Visual Basic .NET language is Visual Studio. VB.NET uses statements to specify actions.

5. RESULT

The paper shows monitoring of patients taking into consideration their physical parameters like the body Temperature and Heartbeat. The embedded system will consider the inputs it has received from these two sensing devices and generate an outcome with respect to the predefined software calculations. The final result of the outcome will be compared to the defined thresholds and a data log of the result will be generated. The patient's condition can be monitored remotely and continuously with the help of ZigBee transmitter and ZigBee receiver. If the values generated in the data log do not appear in between the defined thresholds an alert message will be generated. The alert message will be sent to all the predefined mobile numbers that are attached to the person under consideration with the help of GSM module. The alert messages will symbolize that the patient under the system's observation has developed some critical condition and needs to be attended immediately. In general cases, the data log will contain the time-to-time health parameters as generated by the embedded system and the list of medicines prescribed by the doctor. The data log will be in the form of a GUI interface and will help the doctor to study about the patient's history. This data log will also help the doctor to decide the medical course for the patient. The data log will also help caretakers to provide primary treatment to the patient in case of doctor's absence.

6. CONCLUSION

The Patient Monitoring system has great potential in improving problems in today's emergency response system. Any abnormalities in health conditions are informed via SMS to the indicated mobile number through GSM. The feature of information gathering, processing data, and storing data from ZigBee and GSM that helped in monitoring of patients was studied. This technology can also be setup at the patient's own house with the assistance of the family. Home care represents a growing field in the health Assistance. It reduces costs and increases the quality of Life saving of patients. As the modern life becomes more stressful and acute diseases appear, prolonged treatments become more necessary. The same occurs for the elderly or handicapped patients. It reduces the need of transporting patients between house and hospital. Recent studies conclude that early and specialized prehospital management contributes to emergency case survival. The only limitation that poses a problem with the functioning of this setup is that the network may pose a problem during the sending of message with the GSM module.

7. FUTURE SCOPE

- The following measurements can be done in future: Blood pressure, Pulse oximetry and, Galvanic-Skin Resistance, Amenia. Similarly, we can also use SY-HS-220 which is the humidity sensor module used to measure humidity for the patients suffering from asthma.
- In future we can use various sensors like ECG sensor, SPO2 sensor, Saline level sensor, MEMS Sensor etc.
- Using GPS, the location of remote patient can be detected so that help can be provided in case of emergency from nearest hospital.
- In this project Doctor and other hospital staff can manage only one patient at a time. But in future Doctor can remotely monitor multiple patients at a time while walking in Hospital campus. For that we can develop an android application. By using this application Doctor can monitor multiple patients at a time and for that this android application will connect wirelessly with ZigBee module. And doctor using his Hand device like mobile, Tablet and other gadgets he can manage patients very easily.

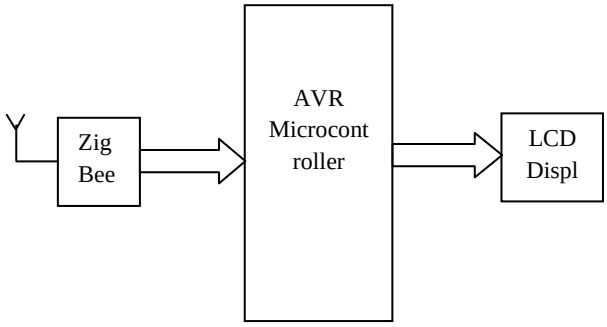


Figure 10. Block Diagram for Doctor's Hand Device

- Other future applications of our project are shown in the below diagram

Figure 11. Other Future Applications of Patient Monitoring

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