International Journal On Engineering Technology and Sciences – IJETS™
ISSN(P): 2349-3968, ISSN (O): 2349-3976
Volume II, Issue IX, September - 2015

REMOTE HEALTH MONITORING USING INTERNET OF THINGS (IOT)

Prabhakaran R[1], Jili k p[2]

[1]Asst. Professor, [2]PG Student, Dept. of ECE, Venkateshwara Hi-Tech Engineering College, Gobi, India.
E-Mail:krish.nanjili@gmail.com

Abstract-- project describes the monitoring human health using Internet Of Things (IOT) from a remote location .The main aim of this project is a doctor can monitor individual health condition from anywhere in the world. This can be achieved by fetching the measured data from the Sensor node located on individual premises and send the same to the Central Node through wireless communication modules . This data can upload to the web world which could be accessed by the doctor using a web interface. Sensor Node: This includes two sensors for measuring patient body temperature and Heart beat. These measured parameters can be transmitted to the Central Node using Zigbee Module. The microcontroller PIC16F877A act as the brain of this node. Central Node: This includes Zigbee modules which collect the measured parameters from Sensor Node. This data should be processed and uploaded to the internet world using a web interface. A GSM module is connected to send the critical condition to the doctor.ARM LPC2368 is the brain of this node

Keywords – Sensor node(PIC 16F877A),Central node(ARM LPC 2368),Zigbee Module

I. INTRODUCTION

Timely access to health care in both urban and rural settings is a world wide challenge. No nation that is committed to the health of its population can afford to replicate, in every community, all the resources required for comprehensivehealthcare. On the other hand, as the potential for universal Internet access approaches reality, consumer access to health information and portals for health monitoring and the health care-related services is assuming increasing importance. These facts are changing the health care system and re-defining the roles of its players including patients, cliniciens, health éducateurs, hospitals and clinics, public health organisations, and health insurance agencies and companies m The Internet allows patients and family members to acquire, on their own, large amounts of disease-related information . As a result, clinicians who were previously the custodians of health information are increasingly becoming patient and family advisers about the use, relevance and specific applicability of that health information in individual situations. **Remote patient monitoring** (RPM) is a technology to enable monitoring of patients outside of conventional clinical settings (e.g. in (e.g. in the home), which may increase access to care and decrease healthcare delivery costs . Incorporating RPM in chronic disease management can significantly improve an individual's quality of life. It allows patients to maintain independence, prevent complications and minimize personal costs. RPM facilitates these goals by delivering care right to the home. In addition, patients and their family members feel comfort knowing that they are being monitored and will be supported if a problem arises. This is particularly important when patients are managing complex self-care processes such as home hemodialysis. Key features of RPM, like remote monitoring and trend analysis of physiological parameters, enable early detection of deterioration; thereby, reducing number of emergency department emergency department visits, hospitalizations, and duration of hospital stays. The need for wireless mobility in healthcare facilitates the adoption of RPM both in community and institutional settings. The time saved as a result of RPM implementation increases efficiency, and allows healthcare providers to allocate more time to remotely educate and communicate with patients. RPM technology includes daily

monitoring devices such as glucose meters for patients with diabetes and heart or blood pressure monitors for patients receiving cardiac care. Data can be sent to a physician's office by using a special tele health computer system, by using a special software application installed on the patient's Internet-capable computer, smart phone or tablet PC. The data the patient sends is stored in a relational database so the healthcare professional can view the data as a specific instance or as a trend. RPM is frequently used with the elderly and the chronically ill, two groups of people who have high levels of medical need. Remote monitoring techniques allow these patients and their physicians to closely monitor medical conditions and, if need be, intervene. RPM can also reduce the number of clinic visits and hospitalizations, and the duration of hospital stay, which benefits chronically ill elderly patients for whom traveling long distances may be a concern, analysts say. This also reduces the burden on the healthcare workforce. However, financial issues arise, the researchers note. Hospitals also only benefit from remote monitoring if the technology reduces the length of stay, with a reduction in the number of hospitalizations generally resulting in a cut to budgets or reimbursement. Expenses are also incurred on educating patients and healthcare practitioners on how to use RPM devices, and having staff available to respond to clinician alerts. It helps to monitor and control the device status through HTML web pages. Malfunctions from the sensor node report to hospital staff via GSM through SMS.

II. PREVIOUSLY PROPOSED SYSTEM

In the last few years, technological improvement opens new possibilities to healthcare and medicine practice. E-Health monitoring applications have some particularities concerning the importance on data quality. On the one hand, successful healthcare delivery and planning strongly rely on data (e.g. sensed data, diagnosis, administration information); the higher quality of the data, the better will be the patient assistance . On the other hand, these applications are also particularly exposed to a contextual environment (i.e. patients' mobility, communication technologies performance, information heterogeneity) that has an important impact on information management and application achievement. Motivated by these observations, we study the related data quality issues over the specificities of e-Health monitoring system.

III. PROPOSED SYSTEM

Fig. 1 shows the block diagram to overcome disadvantages of existing manual Remote health monitoring.There are three main modules in the system. The first module called the Remote Node or Sensor Node(slave node), which consists of the PIC16F877A processor, a temperature sensor, a heartbeat sensor, a buzzer and a Zigbee unit. The second module is called the central node or Master node and it consists of ARM LPC2368, an Ethernet Controller, USB port and a Zigbee unit via serial port. Finally, the parameters sensed from the sensors are written on web pages using HTML

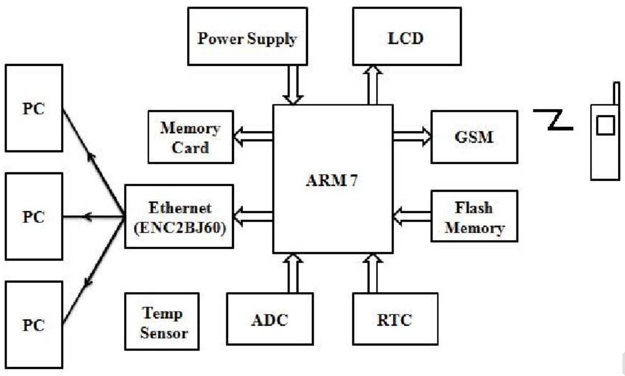


Figure 1- Block diagram of Proposed Architecture

Temperature sensor output and heartbeat sensor output is given to the input of the ADC in PIC16F877A .Then by using appropriate conversion formulae, body temperature and heartbeat count can be calculated any of the calculated value falls beyond the boundary marked as “critical”, the buzzer starts sounding. By using wireless technology, the measured parameters are transmitted to the master node. A GSM modem is interfaced with the master node, which is used to send messages to the doctor if any critical situation is monitored. The received datas in the master node is then uploaded into a web server via Ethernet. By typing the IP-address of the web server on a web browser, the user gets a web page on the screen with all the information about the patient’s health status between central node and sensor node implemented with the help of IEEE 802.15.4 standard.

Sensor Node : A sensor node should be small in size, consume extremely low energy, operate in high volumetric densities, be autonomous and operate a collection of nodes unattended, and be adaptive to the environment. A WSN is “sensors” organized in to a cooperative network. A WSN can be defined as a network of devices, denoted as sensor *nodes*, which can sense the environment and communicate the information gathered from the monitored field (e.g., an area or volume) through wireless links. Each sensor node contain following basic components shown in Fig.2 .It include processing subsystem

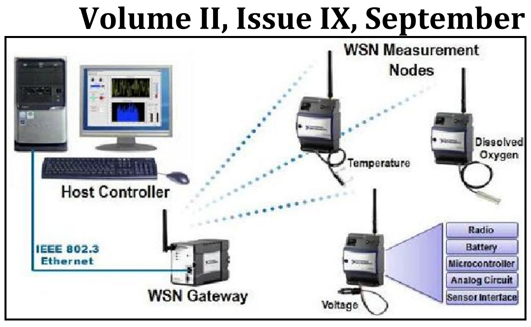
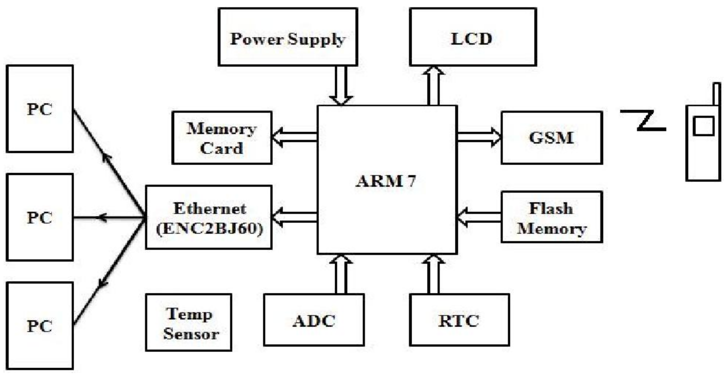


Fig.2.WSN ARCHITECTURE

Microcontroller used as a processing subsystem. The controller performs tasks, processes data and controls Processing subsystem the functionality of other components in the sensor node. A microcontroller is often used in many embedded systems such as sensor nodes because of its low cost, flexibility to connect to other devices, ease of programming, and low power consumption. A general purpose microprocessor generally has higher power consumption than a microcontroller; therefore it is often not considered a suitable choice for a sensor node.

Zigbee is used as a wireless transceiver, which follows IEEE 802.15.4 standards. both transmitter and receiver are combined into a single device known as a transceiver. Radio frequency based communication is the most relevant that fits most of the WSN applications. WSNs tend to use license- free communication frequencies: 173, 433, 868, and 915 MHz and 2.4 GHz. Current generation transceivers have built-in state machines that perform some operations automatically. Most transceivers operating in idle mode have a power consumption almost equal to the power consumed in receive mode.

Sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process. A wireless sensor node is a popular solution when it is difficult or impossible to run a mains supply to the sensor node. However, since the wireless sensor node is often placed in a hard-to-reach location, changing the battery regularly can be costly and inconvenient. An important aspect in the development of a wireless sensor node is ensuring that there is always adequate energy available to power the system. Power is stored either in batteries or capacitors. Batteries, both rechargeable and non-rechargeable, are the main source of power supply for sensor node Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure. Sensors measure physical data of the parameter to be monitored. The continual analog signal produced by the sensors is digitized by an analog-to-digital converter and sent to controllers for further processing. All **sensors** need to be calibrated with respect with some reference value or standard



device for accurate measurement

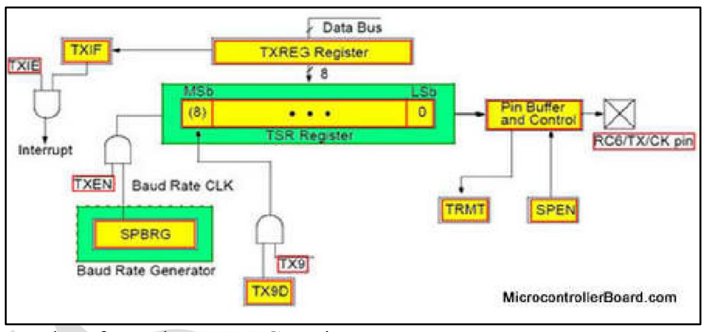
Central node acts as a software defined control center with embedded web server. The embedded web server is a practical approach of the implementation of TCP/IP protocols on a microcontroller. By implementing TCP/IP stack on a microcontroller, we can control and monitor device status through a web page. Central node receives data's from sensor nodes through Zigbee transceiver and performs data analysis and detects malfunction through data processing and malfunction report to the maintenance staff using GSM modem. By typing the IP-address of the web server on a web browser, the user gets a web page on the screen with all the information about the oilwell. Hence oil wells can be monitored from anywhere in the world via internet .

Hardware implementation is divided in to two modules Sensor Node Hardware Implementation and Sensing Hardware. Microcontroller **PIC16F877A** is one of the PICMicro Family microcontroller which is popular at this moment, start from beginner until all professionals.Because of easy usage of PIC16F877A and use FLASH memory technology so that can be write-erase until thousand times. The superiority this Reduced Instruction Set Computer (RISC) microcontroller compared to with other microcontroller 8-bit especially at a speed of instructionand his code compression. **PIC16F877A** have 40 pin by 33 path of I/O. The PIC16F877A CMOS FLASH based 8-bit microcontroller is upward compatible with the PIC16C5x Set Computer (RISC) microcontroller compared to with other microontroller 8-bit especially at a speed of PIC12Cxxx and PIC16C7x devices .

The PIC16F877/876 devices have 8K x 14 words of FLASH program memory and the PIC16F873/ 874 devices have 4K x 14. Accessing a location above the physically implemented address will cause a 0000h and implemented address will cause a the interrupt vector is at 0004h. The PIC16F87X devices have a 13-bit program counter capable of addressing an 8K x 14 program memory . The data memory is partitioned into multiple banks which contain the General Purpose Registers and the special function register.Bits Bits RP1(STATUS<6>) and RP0 (STATUS<5>) >) are the bank select bits Some of the I/O ports pins are multiplexed with an alternate function for the peripheral AQQthat pin may not be used as a general purpose I/O pin.

The Analog-to-Digital (A/D) Converter module has five inputs for the 28-pin devices and eight for the other devices The analog input charges a sample and hold capacitor. The output of the sample and hold capacitor is the input into the converter. The converter then generates a digital result of this analog level via successive approximation. The A/D conversion of the analog input signal results in a corresponding 10-bit digital number. The A/D module has high and low voltage reference input that is software selectable to some combination of VDD, VSS, RA2 or RA3. The A/D converter has a unique feature of being able to operate while the device is in SLEEP mode. To operate in sleep, the A/D clock must be derived from the A/D's internal RC oscillator.

Universal Serial Asynchronous and Synchronous Receiver And Transmitter is a serial communication interface which uses two lines for sending (TX) and receiving (RX) data. As its name indicates it is an asynchronous communication interface, which means it doesn't need to send clock along with it as in synchronous communications. UART is the communication standard of our old computer's RS-232 serial port. Most of the Microchip's PIC Microcontrollers have built in USART Module. The USART module associated with four registers. These registers are: Transmit Status and Control Register (TXSTA), Receive Status and Control Register (RCSTA), Baud Rate Generator Register (SPBRG). The USART transmitter block diagram is shown in Fig 3 . The heart of the transmitter is the Transmit (Serial) Shift Register (TSR). The shift register obtains its data from the Read/Write Transmit Buffer, TXREG. The TXREG register is loaded with data in software. The TSR register is not loaded until the Stop bit has been transmitted from the previous load. As soon as the Stop bit is transmitted, the TSR is loaded with



new data from the TXREG register

Fig.3. USART TRANSMITTER BLOCK DIAG

PWM is a powerful technique used to generate analog voltage using digital signals. It has a wide variety of applications such as controlling average power delivered to a load, generating analog voltage level, sine wave generation and DC Motor speed control. CCP Modules are available with a number of PIC Microcontrollers which can be used to generate PWM waves. CCP Stands for Capture/Compare/PWM. PIC16F877A has two CCP modules named as CCP1 and CCP2.CCP modules use Timer 2 for their operation. Period of the generated PWM waves is determined by the value in the PR2 register. Values of Timer 2 and PR2 are compared every-time using a comparator. When these values become equal, Timer 2 will be reset and output will become HIGH. Duty cycle is determined by the value in CCPR1L and CCP1CON<5:4>. These registers can be written any time.

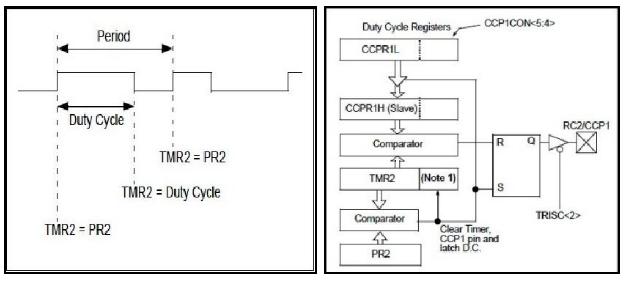


Fig.4. PWM WAVE AND MODULE

PIC16F877A has inbuilt 10 bit up to 8 channels Analog to Digital Converter. The internal ADC of the microcontroller is used to convert the analog output of the sensor into its equivalent digital value and microcontroller performs analysis on this data and then transmitted through UART. Different sensor like LM35, PRESSURE, ADXL, VOLTAGE and CURRENT are interfaced through this ADC module as shown in figure 5

In this project the reference voltage to the ADC is same as the supply voltage to the microcontroller i.e. 5V.

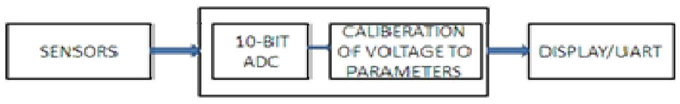


Fig.5 BLOCK DIAGRAM OF ADC INTERFACING

The sensor can measure temperature in the range of 0 to 100°C, i.e., the output of the sensor varies from 0 to 1000 mV. The LM35 operates over the temperature range of -55° to +150°C, while the LM35C is rated for a -40°C to +110°C range (-10°C with improved accuracy). Analog output of LM35 is connected analog input channel AN0 of the processing subsystem. The output voltage and the temperature are related by the following formula:

$$\text{Temperature} = ((\text{ADCRead\_Value})/1023.0) * 5 * 100)$$

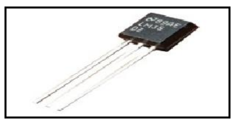


Fig.6 LM 35-TEMPERATURE SENSOR

SCI is an abbreviation for Serial Communication Interface and, as a special subsystem of microcontroller PIC16F877A. It contains all clock generators, shift registers and data buffers necessary to perform an input/output serial data transfer independently of the device program execution. As its name states, apart from using the clock for synchronization, this module can also establish asynchronous connection, which makes it unique for some of the applicationsIn this project USART operated in full duplex asynchronous transmit and receive mode. In asynchronous mode transmits and receives data using a standard non-return-to-zero (NRZ) format. As seen in figure 6, this mode doesn't use clock signal, while the format of data being transferred is very simple. The duration of the stop bit 'T' depends on the transmission rate and is adjusted according to the needs of the transmission. For the transmission speed of 9600 baud, T is 104µs.

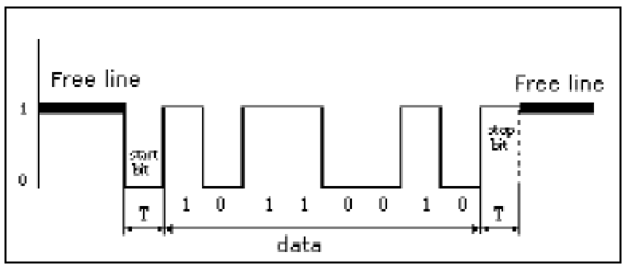


Fig.6. NRZ FORMAT DATA

The MAX232 IC is used to convert the TTL/CMOS logic levels to RS232 logic levels during serial communication of microcontrollers with Data Terminal Equipment (DTE) like PC. Here Zigbee is act as a DTE. The controller operates at TTL logic level (0-5V) whereas the serial communication in PC works on RS232 standards (-25 V to + 25V). This makes it difficult to establish a direct link between them to communicate with each other. Therefore we need an intermediary stage that will convert the levels. One chip specially designed for this task is MAX232. This chip receives signals from -10 to +10V and converts them into 0 and 5V. Figure 7 shows DB9 connector along with MAX232 IC from NSK electronics.

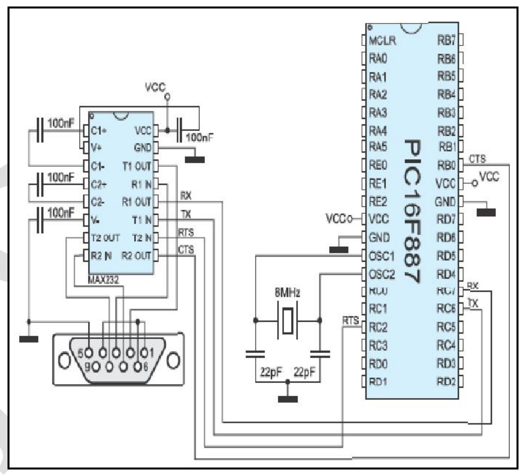
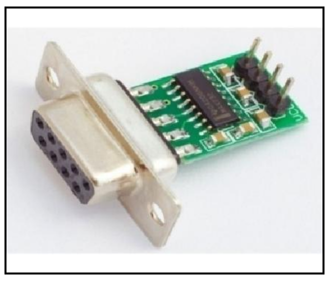


Fig.7 MICROCONTROLLERWITH MAX232



DB9 CONNECTOR

The Zigbee standard provides for the connectivity of simple fixed and mobile devices that require only low data rates between 20 and 250Kbps, consume a minimum amount of power, and typically connect at distances of 30- 100 meters. The Zigbee Alliancewas formed in 2002 to create a set of specifications for low power, cost effective, wirelessly networked products for monitoring and control. The requirements for monitoring sensors, sometimes called nodes, and control systems are different from those of wireless computer networks. . Its main purpose is to create a network topology (hierarchy) to let a number of devices communicate among them and to set extra communication features such as authentication, encryption, association and the upper layer application services. It was created by a set of companies which from the Zigbee Alliance. As mentioned before IEEE 802.15.4 protocol lies over the level two (Data Link Layer) of the OSI. Here the digital information units (bits) are managed and organized to become electromagnetic impulses (waves) on the lower level, the physical layer. This layer is similar to others known ones such as the 802.11 (commonly named under Wi-Fi technologies) or the common Ethernet (802.3).

The protocol stack is based on the OSI seven-layer model but defines only those layers that are relevant to achieve specific functionality required in the market place. The Zigbee protocol stack is shown in Fig 8. Its most important characteristics are:

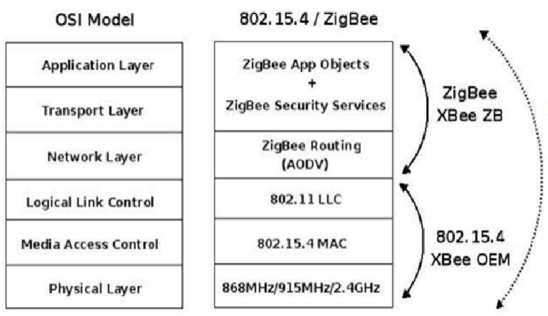


Fig.8.PROTOCOL STACK

- Two PHY layers that operate in two separate frequency ranges: 868/915 MHz and 2.4 GHz. The PHY layer in Zigbee device is responsible for turning the radio transceiver on and off, detecting the presence of an RF signal in the currently selected channel, analyzing and reporting link quality for received packets, assessing whether the channel is clear before initiating the transmission, selecting a frequency channel for operation, and transmitting and receiving data.

- The MAC sub layer that controls access to the radio channel. Its responsibilities include synchronization and providing a reliable transmission mechanism (error checking).

- The Logic Link Control (LLC) sub layer that complies with the IEEE 802.2 LLC, and is responsible for managing the data-link communication, link addressing, frame sequencing.

The upper Zigbee layers include mechanisms used by the devices to join network, which is called **association**, leave a network **(dissociation)**, apply security to frames, and perform routing

ARM7 LPC2368 processor act as heart of a central node. LPC2368 is based on a 16-bit/32-bit ARM7TDMI-S CPU. It has a 512KB of embedded high-speed flash memory. It incorporates a 10/100 Ethernet Media Access Controller (MAC), four UARTs, two CAN channels, an SPI interface, 10-bit DAC, one PWM unit and up to 70 fast GPIO lines.

The LPC23xx includes an Ethernet Media Accesses Control (MAC) sub layer. The Ethernet MAC is designed to interface to an external Ethernet Physical layer (PHY) to make a complete Ethernet controller which is fully complaint to the IEEE 802.3 standard and supports 10 and 100 Mbps full duplex communication. The Ethernet MAC is located on its own dedicated Advance High Performance Bus (AHB), along with 16KB SRAM and its own dedicated scatter and gather DMA unit as shown in Fig 6. This subsystem of Ethernet MAC, SRAM, DMA and high speed bus makes the LPC2368 ideal for high performance TCP/IP applications. The Ethernet MAC consists of an interface to the AHB bus, this provides separate ports fortransmit and receive DMA channels and a port for the user registers. The Ethernet MAC consists of an interface to the AHB bus, this provides separate ports fortransmit and receive DMA channels and a port for the user registers. The Ethernet MAC has independent transmit and receive paths. The transmit path includes a DMA manager and transmit flow control with error handling. The receive path includes a DMA manager receiver buffer and receive filter.Ethernet data frames are stored in multiple user defined buffers within the SRAM. Transfer of data between the Ethernet MAC and the SRAM is controlled by dedicated TX and RX DMA unit.Transmit and receive path are interfaced to the external Ethernet PHY via one of the two standard interfaces. The two physical interface options are Media Independent Interface (MII) and Reduced Media Independent Interface (RMII). The Ethernet peripheral special function registers can be divided in to four main blocks

The MAC registers consists of a block of seventeen registers that are used to enable the Ethernet MAC and interface it to the external PHY and the Ethernet network. The two MAC configuration registers are used to set the basic operating parameters of the Ethernet MAC. The MAC1 register allows you to perform a soft reset of the Ethernet MAC sub module. The MAC1 register also allows you to enable TX and RX flow control. The MAC2 register controls the handling format of Ethernet packets. In the MAC2 register we can select between full or half duplex operation. There are also options to control the padding out of short Ethernet frames and to control the CRC generation.

The external PHY chip can be connected via the standard MII or RMII interface. The external PHY chip is managed through the MII registers. These registers allow you to read, write and monitor the internal registers of the PHY chip. The MII Address register contains a five bit address field that allows you to specify the address of the internal PHY register. Once this address is selected you can read and write data via the MII read and MII write register. Finally Ethernet MAC address is held in the station address registers. The three station address registers each hold two bytes of the Ethernet MAC address.

Once the Ethernet MAC has been configured, the transfer of network packets will be held by the Ethernet DMA unit. 16KB of SRAM located on the Ethernet AHB bus is used to hold an array of buffers, which contain Ethernet frames or frame fragments. The data in these buffers is transferred into the Ethernet MAC s required for transmission. This process is controlled by a set of DMA descriptors that are setup in the Ethernet RAM and provide the configuration information for each DMA transfer The TX and RX DMA units read a table of buffer descriptors and return a table of DMA status words. The CPU manages these descriptors to control the flow of data through the Ethernet MAC.

One of the most important conclusions from the early tests of the new GSM technology was that the new standard should employ Time Division Multiple Access (TDMA) technology. After a series of tests, the GSM digital standard was proven to

International Journal On Engineering Technology and Sciences – IJETS™
ISSN(P): 2349-3968, ISSN (O): 2349-3976
Volume II, Issue IX, September - 2015

work in 1988. With global coverage goals in mind, being compatible with GSM from day one is a prerequisite for any new system that would add functionality to GSM. As with other 2G systems, GSM handles voice efficiently, but the support for data and Internet applications is limited. A data connection is established in just the same way as for a regular voice call; the user dials in and a circuit-switched connection continues during the entire session. If the user disconnects and wants to re-connect, the dial-in sequence has to be repeated. This issue, coupled with the limitation that users are billed for the time that they are connected, creates a need for packet data for GSM.A unique feature of GSM is the Short Message Service (SMS), which has wide popularity. SMS is a bi-directional service for sending short alphanumeric message in a store-and-forward process. SMS can be used both 'point-to-point' as well as in cell-broadcast mode. Supplementary services are provided on top of tele services or bearer services, and include features such as, call forwarding, call waiting, caller identification, three-way conversations, and call-barring.

A GSM modem is utilized in the surveillance management system of this project for generating user alert SMS. GSM modem used is 'rhydoLABZ's GSM UART Modem – SIM300S is shown in Fig 5.14. The most important feature of this modem is that it can operate from a 5V power supply. But most of the other GSM modems available in the market need either a 7.5V power supply or a 12V power supply to work with.

The 'rhydoLABZ's GSM UART Modem – SIM300S' is an industrial standard GSM module with the external aluminum casing. It is built with Dual Band GSM engine (chip) - SIM300S_V6.02 (070614) which can work on 900/ 1800 MHz frequencies. The onboard low dropout power supply allows connecting wide range unregulated power supply (5V-12V). Using this modem, we can make audio calls, send SMS, read SMS and attend the incoming calls through simple AT commands. The baud rate is also configurable from 9600-115200 through AT commands. The GSM/GPRS Modem is having internalTCP/IP stack to enable us to connect with internet via GPRS.

Fig.9.GSM MODEM

.

IV. APPLICATIONS

Wireless sensor technology finds a lot of applications in the remote health Wireless technology enables a new range of applications; particularly in the area of health, safety and environment. Networks may be composed of many different types of sensors such as ECG, Glucose level sensor and many others which are able to monitor a wide variety of ambient conditions. Beside of monitoring and managing applications, the ambient monitoring sometimes is extremely necessary to the human and environment safety.

V.RESULT AND DISSCUTIONS

The project "Remote Health Monitoring Using IOTs" was successful in achieving its primary goal. Under the project the ARM LPC2368 was successfully configured as HTTP web server. After the software and hardware have been completed the generated codes are compiled and downloaded to the target device. But the real implementation of Remote Heath Monitoring is much more complex work and will require a lot of effort. So this project implemented a prototype of Remote Heath Monitoring. If a client wants to monitor the status of parameters, the IP address of web server is to be given on the remote host. As a result, the HTML web page stored on the web server is opened and it shows the real time parameters. Figure 10 shows the sensor node prototypeand figure 11 shows Web page.

Fig.10 SENSOR NODE PROTOTYPE

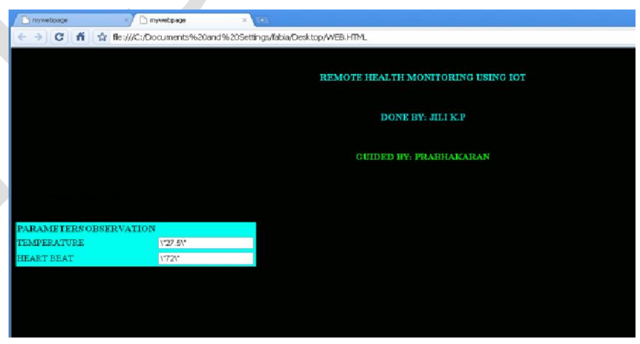


Fig.11 WEB PAGE

CONCLUSION

Conventional monitoring and data collection methods, which require physical presence at the hospitals, could in many cases be replaced by remote monitoring over the internet. In this paper, a sensor network based remote health monitoring and intelligent control system was proposed. This proposed system consists of a sensor node and a centralized node. The sensor node consists of a temperature sensor and a heartbeat sensor for health parameter data sensing and monitoring. Sensor nodes monitoring health conditions send data wirelessly to a central node using Zigbee. The central node acts as a software defined control center and it is designed for hundreds of data storage/management, data processing and uploading to web server.

REFERENCES

1.D. Raskovic, V. Revuri, D. Giessel, and A. Milenkovic, "**Embedded Web Server for Wireless Sensor Networks**", National Consortium for MASINT Research under DIA / NSF Grant No.11S-0434156

2.Gill, K. ; Shuang-Hua Yang ; Fang Yao ; Xin Lu, "**A zigbee-based home automation system**" IEEE Transactions on Consumer Electronics, Volume: 55 , Issue: 2 DOI: 10.1109/TCE.2009.5174403 Publication Year: 2009

3. Hoi Yan Tung, Kim Fung Tsang, *Member, IEEE, Hoi Ching Tung, Kwok Tai Chui and Hao Ran Chi*, "**The Design of Dual Radio ZigBee Homecare Gateway for Remote Patient Monitoring**" IEEE Transactions on Consumer Electronics, Vol. 59, No. 4, November 2013

4. Jeffrey Wieselthier, Gam Nguyen, and Anthony Ephremides. (2000) "On the construction of energy-efficient broadcast and multicast trees in wireless networks". proceedings of IEEE INFOCOM, Tel-Aviv, Israel

5.Kwon.T.J. and Mario Gerla.(1999) "Clustering with Power Control". In Proceedings of IEEE MILCOM, Atlantic City .

6. Le Boudec. J Y and Vojnovic M (2005) "Perfect simulation and stationary of a class of mobility models", in Proc. IEEE INFOCOM, pp. 2743–2754.

7.Maleki. M, Dantu. K and Pedram. M (2003) "Lifetime prediction routing in mobile ad hoc networks" ,in Proc. IEEE WCNC, pp. 1185–1190.