Advanced Network Based Wireless, Single PMS for Multiple-Patient Monitoring

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***Abstract*—Real-time monitoring of the physical condition of the patients is one of the major challenges faced by hospital authorities nowadays. All the hospitals today have one Patient Monitoring System (PMS) per patient. Also human intervention is needed frequently for critical patients. In this paper we propose a network based Wireless Single PMS (NWSPMS), which can monitor multiple patients to measure various physical parameters. This must be precise, fast and effective for transmission of information about their health condition to the concerned. Also there lies a need to transmit more parameters and more data for the convenience and fast response by the staffs in the hospital. Since we need an immediate response, we make use of the voice-call facility apart from the SMS mechanism via an GSM modem. The system proposed here monitors blood pressure, heart beat rate, body temperature and ECG of the elderly patient thus giving an overall condition of the patient.**

***Keywords*— PMS, GSM modem, ECG, SMS, network.**

I. INTRODUCTION

Giving care and health assistance to the bed ridden patients at critical stages with advanced medical facilities have become one of the major problems in the modern hectic world.

In hospitals where a large number of patients whose physical conditions have to be monitored frequently as a part of diagnostic procedure, the need for a cost effective and fast responding alert mechanism is inevitable. Proper implementation of such systems can provide timely warnings to the medical staffs and doctors and their service can be activated in case of medical emergencies. Present-day systems use sensors that are hardwired to a PC next to the bed. The use of sensors detects the conditions of the patient and the data is collected and transferred using a microcontroller. Doctors and nurses need to visit the patient frequently to examine his/her current condition. In addition to this, use of multiple microcontroller based intelligent system provide high level applicability in hospitals where a large number of patients have to be frequently monitored. For this, here we use the idea of network technology with wireless applicability, providing each patient a unique ID by which the doctor can easily identify the patient and his/her current status of health parameters. Using the proposed system, data can be sent wirelessly to the Central Patient Monitoring System (CPMS), allowing continuous monitoring of the patient.

Contributing accuracy in measurements and providing security in proper alert mechanism give this system a higher level of customer satisfaction and low cost implementation in hospitals. Thus the patient can engage in his daily activities in a comfortable atmosphere where distractions of hardwired sensors are not present. Physiological monitoring hardware can be easily implemented using simple interfaces of the sensors with a Microcontroller and can effectively be used for healthcare monitoring. This will allow development of such low cost devices based on natural human-computer interfaces.

The system we proposed here is efficient in monitoring the different physical parameters of many number bedridden patients and then in alerting the concerned medical authorities if these parameters bounce above its predefined critical values. Thus remote monitoring and control refers to a field of industrial automation that is entering a new era with the development of wireless sensing devices.

II. RELATED WORKS

As a part of the case study related to the various patient monitoring systems, we found that although there are many products of Patient Monitoring System in the market, few of them implemented active network technology and used mobile interface for the alert mechanism. PMS in [1] deals with the constant monitoring of health parameters using a palm-top like device and informing the service providers when ambulating conditions arise. It acts like a point-to-point system. For multiple patients in hospitals, keeping one such system for each patient will become costlier. In [2] the proposed system has the ability to measure various physical parameters of different patients, but it uses the internet facility for conveying the status of patients to the authorities. Paper [3] mainly deals with the software aspects of designing a system which can access the data base which include various health parameters of the patients.

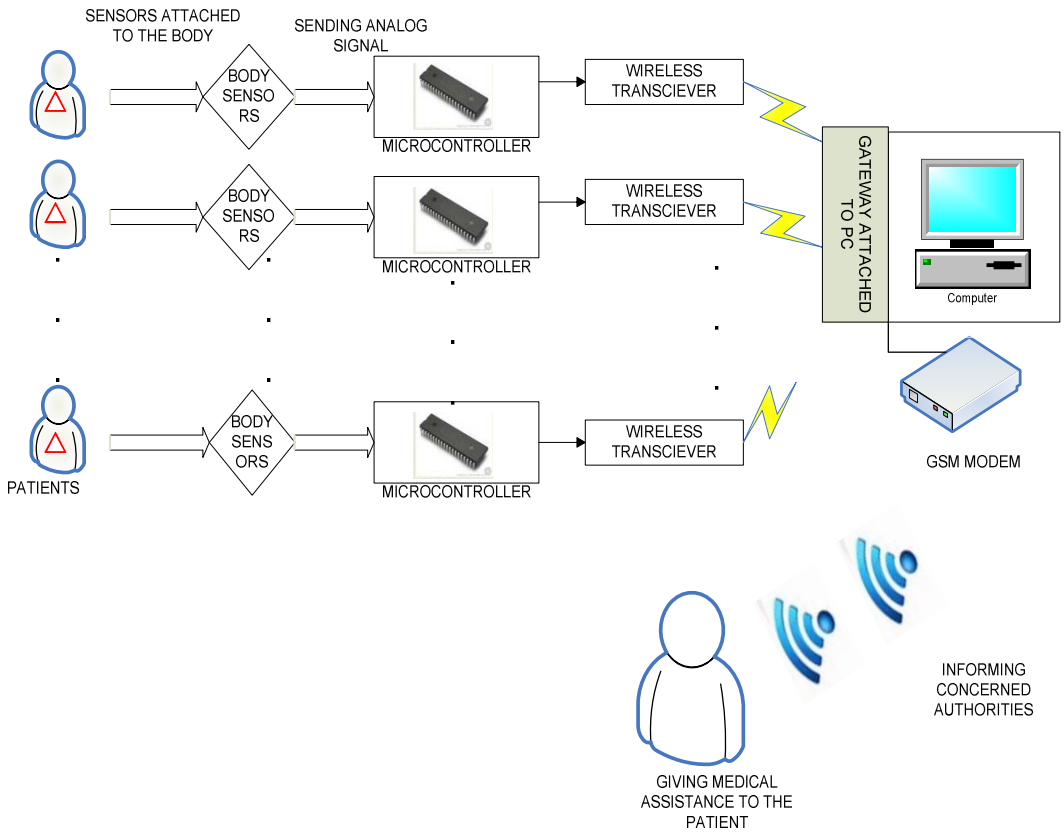

Figure.1. NWSMPS System Design

III. YSTEM DESIGN AND WORKING

In our proposed system we use active network technology to network various sensors to a single PMS. Patients' various critical parameters are continuously monitored via single PMS and reported to the Doctors or Nurses in attendance for timely response in case of critical situations. Our NWSPMS has the following basic components.

- Various sensors attached to the body of the patient.
- Microcontrollers for analog signal interface
- Wireless transmitting and receiving system for data transfer.
- A functional wireless network for different patients with their unique ID.
- A Central Patient Monitoring System (CPMS) observing unit basically a PC.

The sensors are attached to the body of the patients without causing any discomfort to them. In this NWSPMS we monitor the important physical parameters like body temperature, ECG, heart beat rate and blood pressure using the sensors which are readily available. Thus the analog values that are sensed by the different sensors are then given to a microcontroller attached with it.

The microcontroller processes these analog signal values of health parameters separately and converts it to digital values using ADC converter. Now, the digitalized values from more than one microcontroller are sent to the CPMS. Each of the entire sensors attached microcontroller with a transceiver will act as a module which has its own unique ID. Each module transmits the data wirelessly to the gateway attached to the PC of the CPMS. The gateway is attached to the PC i.e. CPMS which is situated in the medical center, is capable for selecting different patient IDs and allowing the gateway to receive different physical parameter values the patient specified by the ID. The software designed using Graphical User Interface (GUI) can operate on different physical parameters of each patient, consecutively with a specified time interval for each patient. At any time any of the doctors or nurses can log on the CPMS and check the history of the observed critical parameters of any of the patient attached to the network. A wireless sensor

mote is attached to the sensor set attached to each of the patients. The gateway of the Wireless Sensor Network is attached to the CPMS.

In case of a critical situation which requires immediate attention of the doctors or nurses for any of the patients, the custom software will instruct the CPMS to enable the GSM modem to send an SMS with the patient ID. A voice call is also made to the doctors and the staffs of the hospital. The SMS also consists of current status of the patient's physical condition .With the help of the patient ID, the doctor can easily identify and attend to the patient situation. Fig 2. shows the flow chart for NWSPMS algorithm.

IV. FLOWCHART

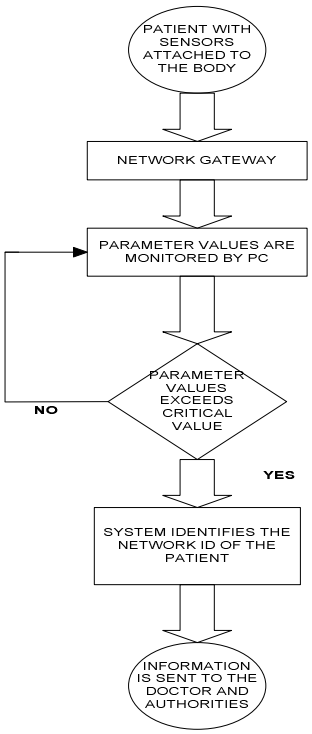

Figure 2. NWSPMS Algorithm

V. SENSORS AND PARAMETERS

To implement the network based multiple-patient monitoring and alert mechanism, we use the following technologies and methodologies which will provide an active and user-friendly environment for the working of the system. Each technology we used are discussed in detail below.

A. Sensor Microcontroller Module

The Sensor Microcontroller module consists of four sensors which could measure parameters like

1) Body Temperature: Temperature sensors in the medical field have been used from time immemorial to measure the body temperature and monitor the medical condition of patients. With a temperature sensor attached to the body of the patients, measurement of absolute temperature of the patient will be accurate, and the system allows for continuous monitoring of a patient's differential change in temperature.

The LM335 series are precision, easily-calibrated, integrated circuit temperature sensors. They are two terminal devices like a zener and have a break down voltage directly proportional to the absolute temperature at +10mv/°K. The LM335 operates in the range of -40°C to +100°C as given in [6].LM335Z can measure temperature ranging from -40°C to +100°C. The output from the temperature sensor is an analog signal and it is fed into the analog input of the PIC16f877A microcontroller.

Inside the microcontroller, the analog output from each sensor is converted to a 10 bit digital value using the ADC module present inside the microcontroller.

The 10 bit ADC converted data is sent to the transmitter of the wireless sensor module via RC6 pin of PIC16F877A using USART module available in the PIC microcontroller.

***2) Blood Pressure*:** Pressure sensors are important in medical conditions where patients have a frequently varying Blood pressure. These sensors will detect the blood pressure in the patient's body. Adding wireless transmission and networking capability will take it to the next level of comfort and sophistication for a number of patients.

Traditional blood pressure monitoring requires a cuff, wrapped around the upper arm and inflated until blood flow is completely cut off. The examiner then gradually releases the pressure, listening to the flow until the pulse can be detected.

With the new monitor as in [4], no cuff is required. Instead, the device takes advantage of a method called pulse wave velocity, which allows blood pressure to be calculated by measuring the pulse at two points along an artery. The two points decided are two points of index figure.

That posed a challenge because blood pressure in the hand varies depending on its position: If the arm is raised above the heart, the pressure will be higher than if it is below the heart. The researchers solved that dilemma by incorporating a sensor that measures acceleration in three dimensions, allowing the hand position to be calculated at any time.

This not only compensates for the error due to height changes, but also allows them to calibrate the sensor for more accurate calculation of blood pressure. As the wearer raises the hand up and down, the hydrostatic pressure changes at the sensor. Correlating the change of pulse wave velocity to the hydrostatic pressure change, the system can automatically calibrate its measurement.

The equivalent analog output signal will be fed to microcontroller.

***3) ECG*:** An ECG sensor is important for patient monitoring system because their analysis give clear information

about cardiac regulation and well insight about pathological conditions. Also, the system should be user friendly, simple, reliable and of affordable cost.

The two electrodes of the ECG sensor are connected to the body as in [5] and the signals collected are amplified by means of op-amps (LM358N) so as to interface it with the PC. The gain of the op-amp is controlled by varying the resistors attached to it. Fig. 3 shows the ECG sensor circuit diagram.

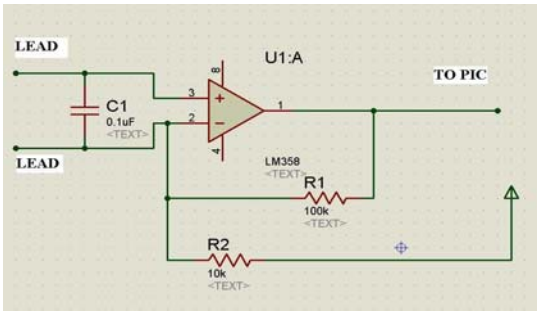

Figure.3. ECG Sensor Circuit

Here we are using two op-amps so as to reduce the effect of noise generated while sensing.

***4) Heart Rate*:** Heart rate is the number of heartbeats recorded per minute typically recorded as Beats per Minute (BPM) as in [7]. In the proposed system, we make use of a technique called Photoplethysmography (PPG). PPG is a simple and low cost optical technique that can be used to detect the blood volume changes in the micro vascular bed of tissues. In this technique, a bright led and a LDR is employed to detect the blood flow at the finger tip or any other peripheral part of the body. The light from the bright led gets reflected from the tissues in the body parts and the amount of light reflected determines the volume of blood flowing. If more blood flows through it, more light is reflected back.

We have to amplify the signal and remove the unwanted noise signals. For this purpose we make use of operational amplifiers, LM358. The circuit is shown below in Fig. 4.

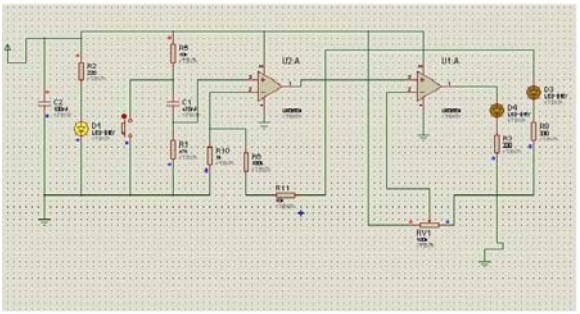

Figure.4. Noise Filtering Circuit

B. Network Setup

The above mentioned sensor-microcontroller module is unique for each patient when each module is attached with a wireless transceiver. Also the network thus formed has the capability to communicate with the gateway attached to the receiver end (i.e. The Central Monitoring System).

C. SMS and Voice Call Gateway

A GSM (Global System for Mobile Communication) modem is used to alert the caretakers when there is a abrupt change in the measured parameters.

VI. EXPERIMENTAL SETUP

The modem which we are using is GPRS/GSM modem. GSM/GPRS modem can be used to send messages and also make a call through computer. HyperTerminal can be used to control the modem. For interfacing HyperTerminal with modem there are some steps which we should follow.

A. Setting up GSM Modem

GSM/GPRS modem is connected to the computer using a RS-232 cable.It is connected to the serial portof the computer. The GSM modem will map itself as a COM serial port in the computer as in [9].

B. Hyperterminal Connfiguration

- On the Windows Start menu, select the Run dialog box.

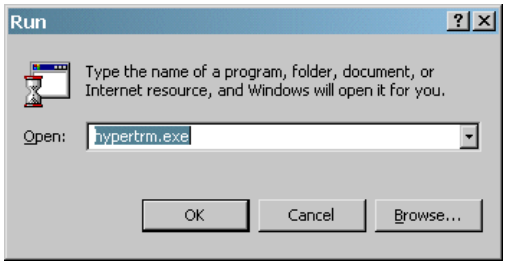

Figure. 5. The Windows Run Dialog Box

- Type hypertrm.exe in the Open field to open the Connection Description screen as shown in Fig.5.
- On the Connection Description screen, for Name, "Cisco" is typed and an icon is selected for the definition. The Connect To dialog box appears
- The primary COM port is selected for the Connect. The COM Properties dialog appears.
- On the COM Properties dialog box, the following selections are made as shown in the Fig 6.

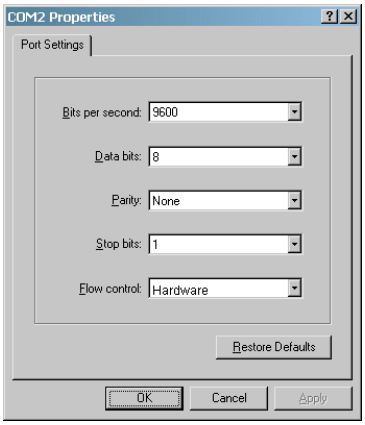

Figure 6. HyperTerminal COM in Properties dialog

Bits per sec: 115200
Data bits: 8
Parity: none
Stop bits: 1
Flow control: Hardware

C. Setting up initially by AT Commands

We are now ready to start working with AT commands to setup and check the status of the GSM modem as shown in [10].

AT	Returns a "OK" to confirm that modem is working
AT+CPIN="xxxx"	To enter the PIN for the SIM
AT+CREG?	A "0,1" reply confirms that modem is connected to GSM network
AT+CSQ	Indicates the signal strength, 31.99 is maximum.

D. Sending SMS through AT Commands.

AT+CMGF=1	To format SMS as a TEXT message
AT+CSCA="+xxxx"	Set the SMS center's number. Check with the provider.

To send a SMS, the AT command to use is AT+CMGS.
AT+CMGS="+yyyyy" <Enter>
> The SMS text message here <Ctrl-Z>AT The "+yyyyy" is the recipient's mobile number.

E. Making call using AT commands.

- In the blank HyperTerminal window, type atz and then press Enter. The modem should respond with OK. If the modem does not respond or does not respond with OK, it is not configured properly in Windows.
- Type at+fclass=1 and then press Enter. The modem should respond with OK. If the modem responds with Error, type at+fclass=2 and then press Enter. If the modem does not respond with OK, the modem does not support faxing, or is not properly configured for faxing.
- In the HyperTerminal window, type atdt<phone number> and then press Enter. **NOTE:** The <phone number> refers to the exact dialing sequence of a number. If you need to dial a prefix, add it here as well. You should hear modem pick up and dial the number.
- In the HyperTerminal window, type atz and press Enter. You should receive an OK.
- Close HyperTerminal.

VII. FUTURE WORK

The scalability of the proposed system opens for a wide range of applicability in Multispecialty hospitals where many number of critical care units is present. The scalability is achieved by the networking facility which provides multiple Sensor-Microcontroller modules to send data consecutively to the gateway attached to the PC. Along with this, expanding the project to allow two way communications between doctors and patients, will be beneficiary in many cases where patient needs to communicate directly to the doctor. This will allow doctors to send messages to the patients, and thus make the consultation and service provision more transparent and effective.

VIII. CONCLUSION

By implementing active network based wireless technology with sensor-microcontroller module, our proposed NWSPMS which is responsible for monitoring the health of many number of patients in the same critical unit. The system proposed above is the cheapest system that can be used for this purpose. One of the important beneficiaries of the system is the doctors who can monitor the physical and medical conditions of their patients from any part of the world and thus he can give instructions to others to attend to the patient. Thus the proposed system is in other words an e-hospital system, where the doctor and the patient can attend to many patients at a time .Since it is a continuous monitoring system, the doctor would be able to give clear and best instructions within the least time. By applying this scalability of the proposed system in the rural areas where healthcare facilities are most needed, the system can act as bride between the rural patient and the urban medical service provider. The further work in this topic will focus on the possibility of an effective and cheap home automation system which can be realized by reducing the number of sensor-microcontroller module to a single unit.

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