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Wireless Sensor Network For Patient Health Monitoring System

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Abstract - *Patient health monitoring system consist of wireless sensor network (WSN). WSN is crucial technology. Patient's pulse rate, body temperature and heart beat is monitored automatically by using kit which is associated with patient. Wireless sensor network consist of nodes which collects information which is sent to the central node. Generally central node is PC on which bio signals are monitored. Captured signal is transmitted to central node by using RF module. As automatic monitoring is done, no staff is required to care of patient.*

Key Words: sensor, RF module, WSN, central node, bio signal, automatic

1. INTRODUCTION

The reason for a patient staying in the hospital is not that he or she actually needs active medical care. Often, the principal reason for a lengthy stay in the hospital is simply continual observation. Therefore, efforts have been made to avoid acute admissions and long lengths of stay in the hospital. In recent years, emergency admissions and long lengths of stay have become extremely costly. So the focus of health policy has shifted away from the provision of reactive, acute care toward preventive care outside the hospital. As models of care are redesigned, health economies are seeking to provide more care outside large acute centers. The drivers for this shift are two-fold; first, there is a quality-of-care issue and second, there is a resource allocation issue. Being cared for in a patient's own home is a key aim of current U.K. government health policy and that is driven by an imperative to provide better quality care to people without the need to disrupt their lives.

Currently, some wireless monitoring systems have been designed which commonly use a PC, a personal digital assistant (PDA), or a mobile phone at the patient's side. In these systems, the vital signals are transmitted to the hospital via internet or mobile networks. The main drawbacks of these systems are the costs of a PC or PDA, accessibility, and possible delay that occurs in sending data if the PC is off and the difficulty of using PCs for elderly people. Meanwhile, some of the existing systems transmit signals via an analog radio link to the base station which leaves the signal vulnerable to degradation/hacking during analog radio transmission.

In a wireless sensor network group of sensors monitor and transmit medical signals. Sensors are tailored to a specific condition. In this case, we observe a patient who has suffered a heart attack and is considered at risk for having another attack. This patient would be fitted with electrocardiogram (ECG) sensors that monitor the heart activity, heart rate, and so on. Further, patients are considered as nodes of the network, and the hospital is considered as the central node or sink. These nodes are then connected to a central node which is installed in the hospital. Clinicians are then able to monitor their patients' conditions, detect any abnormalities, and take appropriate action (e.g., contact the patient to give some advice or send an ambulance to their home). This system has particular benefits for patients who want to live their normal lives and for providers who are keen to closely monitor patients but have limited resources or space. In this system, there is no need for a PC to transmit data via internet connection.

Author in [6] elaborated Wireless Mesh Network. Wireless Mesh Networks (WMN) are multihop networks of wireless router platforms. The wireless routers are typically stationary, but the clients can be mobile. A mesh network can provide multihop communication paths between wireless clients - serving as a community network or a broadband access network for the Internet. WMN are considered cost-effective alternatives to wireless LANs, as there is no necessity to deploy any wired infrastructure to support a mesh network. A number of routing protocols like Dynamic Source Routing (DSR), Adhoc on Demand distance Vector routing (AODV) have been implemented for Adhoc and Wireless LAN Networks.

Wireless Sensor based Mesh Network (WSMN) is an integration of these two technologies - Wireless Sensor Network and Wireless Mesh Network. The sensors being low powered and low memory devices can transmit the information to the nearest mesh nodes and these mesh

nodes can use multihop routing to transmit the information to the backbone networks like the PDA or the terminals.

2. System model

In [7], system model is explained which is shown in Fig. 1. It has two main sections in the system. The first section is the patient home where the ECG signals are detected, amplified, digitized, and prepared in some short packets—which we call wireless packets—to be transmitted to an access point via a wireless channel. The access point then assigns a number for each packet and merges all of them together and sends them via Internet to the hospital, which is the next part of the system. In the hospital section, signals are received and prepared for interpretation by clinicians. The patient home is connected to the hospital through the Internet.

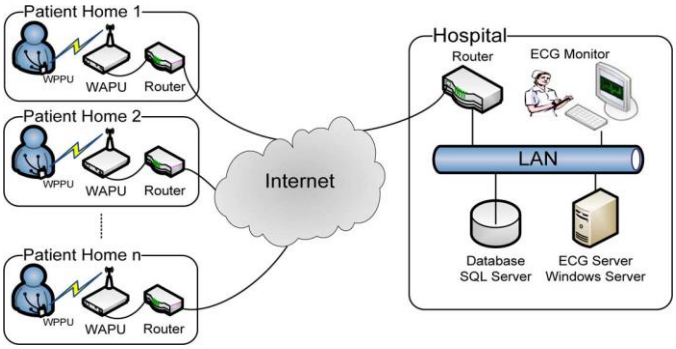

Fig -1: System model

A wireless sensor network is networked and scalable, consumes very little power is smart and software programmable, capable of fast data acquisition, reliable and accurate over the long term, costs little to purchase and install, and requires no real maintenance. Each node in a sensor network is typically equipped with a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery. A sensor network, normally constitutes a wireless Adhoc network, and supports a multi-hop routing algorithm. The base stations are one or more distinguished components of the Wireless Sensor Network (WSN) with much more computational, energy and communication resources. They act as a gateway between sensor nodes and the end user.

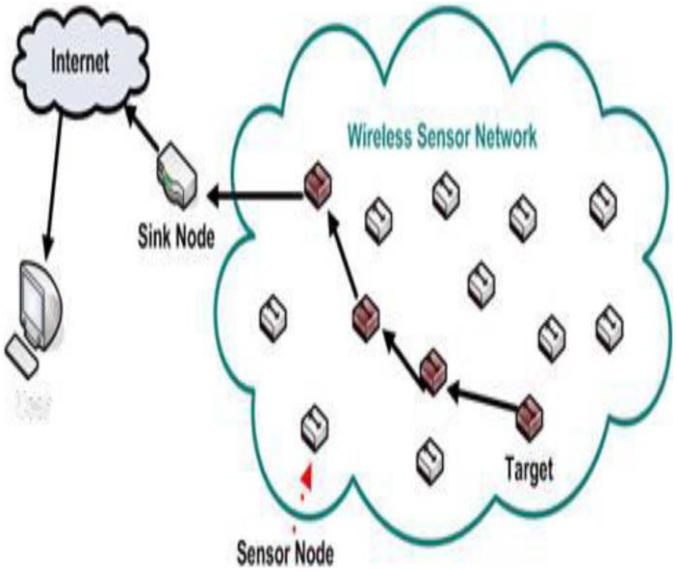

Fig -2: Architecture of wireless sensor network

In the existing system, as shown In Fig. 3, the patient's status is looked up and taken care by some person who has to sit near the patient itself. It is difficult to keep each person for each patient. Hence there is a need of automatic monitoring technique for patients.

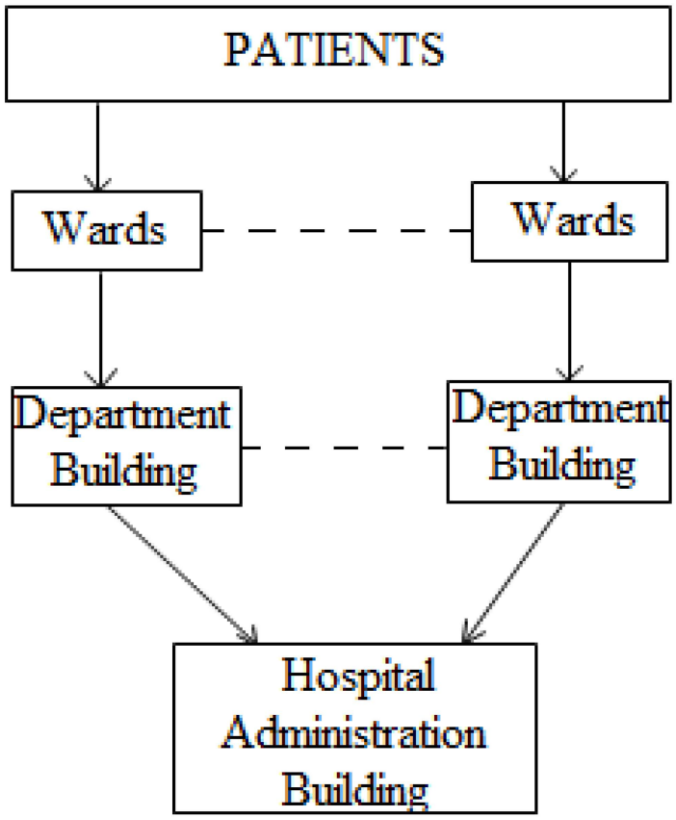

Fig -3: Block diagram of existing system

The module in Fig. 1 consists of ECG sensors, wireless patient portable unit (WPPU) and wireless access point unit (WAPU).

2.1 Wireless Patient Portable Unit (WPPU)

The WPPU block diagram shown in Fig. 4. It consist of two -parts – 1) ECG amplifier and noise cancellation (ECGA and NC) circuits and 2) an RF network-end device board includes a microcontroller and a low-power wireless radio transceiver.

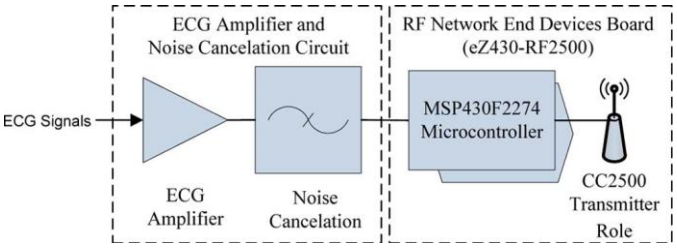

Fig -4: wireless patient portable unit

2.2 Wireless Access Point Unit (WAPU)

The WAPU block diagram shown in Fig. 5 consist of two - parts – 1) the RF network-access point (RFNAP) board and 2) Internet connection board (ICB).

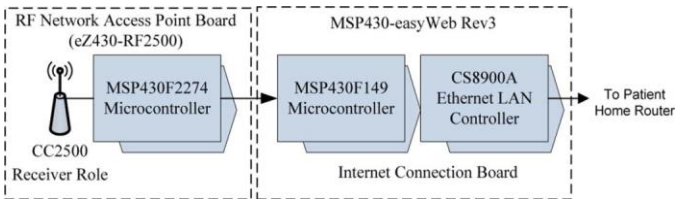

Fig -5: wireless access point unit

2.3 ECG monitoring

The ECG monitoring software visualizes and analyzes the ECG signals. Fig. 6 shows a snapshot of the ECG monitoring application software. Some of the functionalities of this application are as follows:

1) patient database: ability to add, delete, and modify patient information;
2) online plotting: online ECG signals are visualized for more than one patient at any time;
3) offline plotting: plotting of saved ECG signals and the ability to move signals forward and backward;
4)latest recorded ECG signal presentation for multiple users: this feature presents the latest recorded ECG information (i.e., patient name, date, time) for the entire active patients in a single form; the program flags up an alarm signal if there is a delay in receiving data from any of the nodes (patients); this ability greatly helps clinicians or nurses see a problem immediately and take appropriate action for that patient (node).

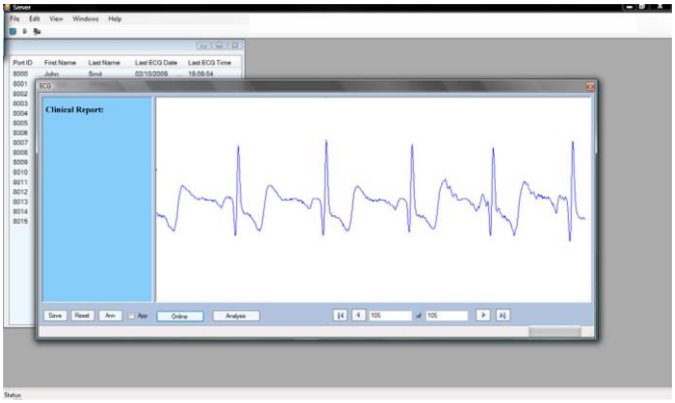

Fig -6: ECG monitoring application view

A mesh network has been deployed using Zigbee technology to send the health status of the patient to a mesh node from where the information is sent to a mobile phone using GSM connection. To achieve this purpose Keil C is used for processing the information in the sensor network and also for sending the information to a terminal using mesh network.

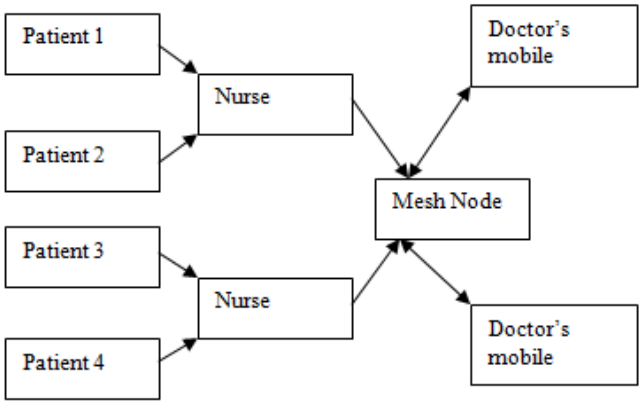

Fig -7: Real time implementation of patient health monitoring system

But with the increasing number of wards and patients inside each hospital building, the mesh node would get overloaded with information from the body sensors from the patients and also the traffic from the doctor's handheld device. Taking this aspect into consideration decentralized hierarchical intelligent agent based architecture has been proposed which is discussed in [6].

This architecture employs two types of intelligent agents that are static and mobile agents. The static intelligent agents in this context stay within the ward of the hospital zone and the mobile intelligent agents move out of ward/hospital zone

to convey the appropriate message to doctors. The mechanism is well described in the Fig.8. The static agent is responsible for the following tasks: acquisition of data from the required body sensor node, filtering of inaccurate and unwanted data, aggregation and processing of useful data, and transmission of the desired results. The mobile agent would deliver the health data so received from Sensors to the mobile phone. Based on the received information, the doctor would attend to the patient immediately.

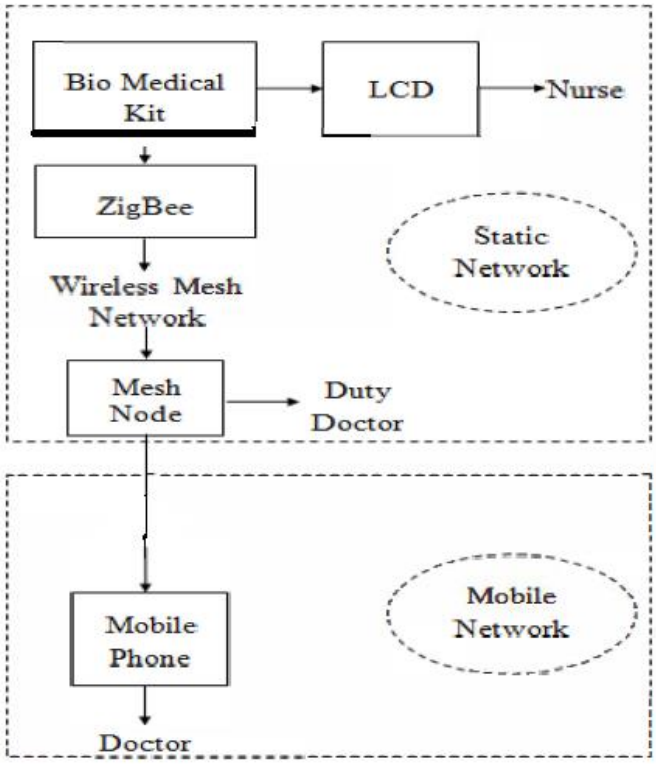

Fig -8: Block diagram of modified system

In [4], The system for home based monitoring of PD(Parkinson's Disease) patients' using RSSI(Received Signal Strength Indicator) values from the sensor motes placed strategically in the patient's room so as to monitor the patient's routine activities is explained which is shown in Fig 9. Sensor motes placed at different locations will communicate with the receiver by continuously sending beacon signals. The receiver or the Base Station (BS) can be a data logger unit or patient's personal computer connected to a receiving sensor mote. BS is capable of storing and analyzing the sensed data and if required, forward it to an emergency medical system. The value of the RSSI at the BS will vary instantaneously when a person obstructs the signal between sender and receiver mote. This change in signal strength can then be used to determine the location of person in a room. Since the sensor motes are extremely small and placed at different locations in patient's room, the system will be completely unobtrusive for the patient monitoring.

An electronic triage that can monitor patients' pulse status remotely through ZigBee-based wireless sensor network is shown in Fig 10. The system consists of a number of SNs, a CN collecting the pulse rate from SNs through ZigBee wireless interface, and a web interface for displaying the graph of patients ' pulse rate. Electronic triage, which is basically an SN, consists of pulse sensor, microcontroller and ZigBee wireless interface . The electronic triage is placed in patients' wrist and the pulse sensor bind the patients ' finger to detect the patients' pulse. The micro controller reads the patients ' pulse from pulse sensor, then classifies into 3 (three) categories of severity levels, i.e., major, minor, and normal status. The patients' pulse status is displayed in unit of beat per minute (BPM) on 1 6x2 LCD. Three LED colors indicate the severity level of patient's status (major: red, minor: yellow and normal: green). If pulse status is between 60- 1 00 BPM, then green LED indicator will turn ON indicating that patient is in good health condition and classified as in the normal status. If the pulse status is between 44 and 60 BPM or between 1 00 and 1 1 6 BPM, then yellow LED indicator will turn ON to indicate that the patient is in close to critical health condition and classified as in the minor status. Otherwise, red LED indicators will turn ON to indicate that the patient in a critical health condition and classified as in the major status. The pseudo-code I shows the algorithm to classify the patients' severity level embedded in microcontroller.

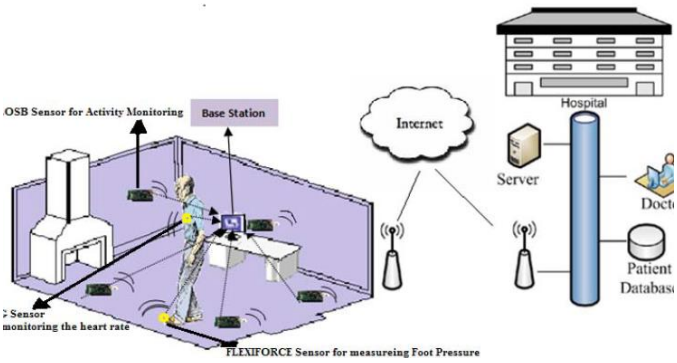

Fig -9: Block diagram of modified system

After classifying the patients' pulse status, the electronic triage will send the pulse status to CN through the ZigBee wireless interface. System consist of XBee Series 2 wireless interface (ZigBee-based protocol) operating in 2.4 GHz frequency band. The XBee series 2 supports point-to-point, point-to multipoint, and mesh communication. It is specified to handle a data transmission rate up to 250 Kbps using 2 m W transmit power that can achieve a distance range up to 120 meters. The CN sends the information of patients ' pulse status to web server. The information is displayed in web interface for allowing medical team to monitor and assess the patients ' condition remotely from anywhere using internet browser. It is possible to restrict the access to the web interface by allowing only the medical team to view this web page.

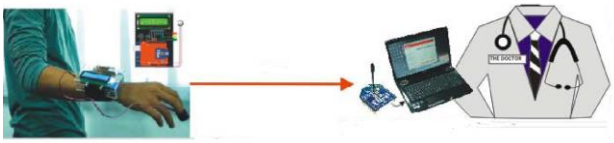

Fig -10: Communication between CN and SN

3. Technologies used

3.1 ZigBee technology

ZigBee is an established set of specifications for a suite of high level communication protocols based on the IEEE 802.15.4-2003 standard for wireless personal area networking (WP AN) digital radio connections between computers and related devices. This kind of network eliminates use of physical data buses like USB and Ethernet cables. The devices could include telephones, hand-held digital assistants, sensors and controls located within a few meters of each other.

ZigBee is one of the global standards of communication protocol formulated by the relevant task force under the IEEE 802.15 working group. The fourth in the series, WP AN Low Rate/ZigBee is the newest and provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. Other standards like Bluetooth and IrDA address high data rate applications such as voice, video and LAN communications.

3.1.1 ZigBee technology advantages

The advantages of ZigBee technology are as follows:
1. The technology defined by the ZigBee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth.
2. The low cost allows the technology to be widely deployed in wireless control and monitoring applications.
3. The low power-usage allows longer life with smaller batteries.
4. The mesh networking provides high reliability and larger range.

3.2 GSM technology

GSM (Global System for Mobile communications) is the most popular standard for mobile phones in the world. Its promoter the GSM Association, estimates that 80% of the global mobile market uses the standard. GSM is used by over 3 billion people across more than 212 countries and territories. GSM differs from its predecessors in that both signalling and speech channels are digital, and thus is considered a second generation (2G) mobile phone system. This has also meant that data communication was easy to build into the system. GSM EDGE is a 3G version of the protocol.
The ubiquity of the GSM standard has been an advantage to both consumers (who benefit from the ability to roam and switch carriers without switching phones) and also to network operators (who can choose equipment from any of the many vendors implementing GSM). GSM also pioneered a low cost (to the network carrier) alternative to voice calls, the short message service (SMS, also called "text messaging"), which is now supported on other mobile standards as well.

3.2.1 GSM technology advantages

The advantages of GSM technology are as follows:
1. Improved spectrum efficiency.
2. International roaming.
3. Low-cost mobile sets and base stations (BSs)
4. High-quality speech
5. Compatibility with Integrated Services Digital Network (ISDN) and other telephone company services.
6. Support for new services.

4. Conclusion

Many hospitals and physicians have requirements for an integrated and reliable wireless monitoring system to observe real-time physiological signals from patients outside the hospital with high and reliable accuracy. Currently available systems for monitoring physiological signals suffer from technical limitations, resulting in the under exploitation of potentially life-saving data. In this paper, a novel wireless sensor network structure to monitor patients with chronic diseases in their own home through a remote monitoring system of physiological signals was presented.

Models used gives complete solution for the problem of appointing a separate person to monitor a patient all the time. The ZigBee technology helps in extending the schematic for the entire hospital, comprising many wards. The smart phone is used to intimate the concerned doctor so that the doctor can be present in any part of the world but still could monitor the patient's health status throughout a day. It also lowers the cost involved with monitoring patients and increases the efficient exploitation of physiological data.

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