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CLOUD BASED DYNAMIC MONITORING OF PATIENT HEALTH PARAMETERS USING RTM-WISE ARCHITECTURE

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ABSTRACT

Health monitoring is regarded as a crucial part in the patient management, since it provides vital data for diagnosis and treatment. The main challenges in current health monitoring devices are the lack of remote monitoring in real time and logging for future evaluation. Typical devices used for health parameter measurement provide basic information regarding health status. A proposal for dynamic monitoring is done to overcome these challenges. A system for patient monitoring using biomedical sensors and displaying it in a remote place is proposed. Constant measurement of health factors such as electrocardiogram, oxygen saturation in blood, heart rate, and surface temperature of the body is incorporated into this system. A prototype is developed to process and transmit the accumulated sensor data to the receiving unit where it is viewed through the implementation of cloud services.

Keywords: cloud computing, health monitoring, pulse oximeter, biomedical sensors, ZigBee protocol.

1. INTRODUCTION

Health monitoring of patients plays a significant role in a population with increased needs in healthcare management. It is regarded as the most important activity to find the physiological response and the effectiveness of any applied medical treatment. Physiological parameters such as oxygen saturation, electrocardiogram, heart rate and body temperature helps identify the health status of the patient. Commercial instruments used for health parameter measurement provide elementary information regarding the health status and often require a certain level of user's attentiveness. These devices lack wireless capabilities or continuous monitoring. Patient monitoring moved to the Internet and was integrated into comprehensive services for chronic patient follow up rather than through telephone lines in the early 90's [12], [13].

The proposed system offers next-generation healthcare technologies emerging as an alternative to the conventional clinical health monitoring systems. A prototype is developed based on the proposed system, which uses biomedical sensors for the above mentioned parameters with wireless sensor networks (WSN) [17] for real time analysis of various health parameters. It is primarily intended to assist doctors diagnose patients remotely. It also supports continuous examination of multiple patients under emergencies. Physicians might use the gathered data to envisage a disease. The primary goal of dynamic monitoring is to give output readout of the measured parameters in real time. Architecture is developed to facilitate real time communication which is stated as RTM-WiSe (Real Time Monitoring in Wireless Sensor networks) architecture. The use of RTM-WiSe architecture helps in increasing responsiveness and security features of the system by suitable techniques. Updating data is in real-time thus enhancing communication between the physician and the remote patient eases identifying the disease more accurately. The dynamic monitoring system finds applications in monitoring patients with critical health state in hospitals, ambulance, home environment and remote areas while physicians is not available in close proximity. The primary perseverance of this paper is to provide an overview of dynamic monitoring of patient health parameters with specific evolving technologies.

The structure of this paper consists the system design for the proposed system which is illustrated in section II. Section III presents the details of various sensors used to monitor patients. Section IV depicts the data communication between different units. Monitoring unit is explained in section V. The proposed RTM-WiSe architecture is elucidated in section VI. The results and the analysis of the proposed model is described in section VII. Section VIII concludes the paper following the references in section IX.

2. SYSTEM DESIGN

The dynamic monitoring system enables continuous monitoring of patient health and conveying the reports to the hospital database through cloud. A simple illustration of the patient monitoring system is shown in Figure-1.

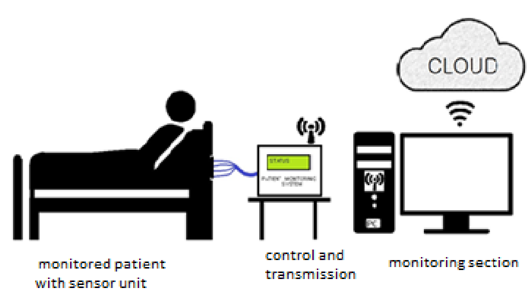

Figure-1. General illustration of dynamic monitoring system.

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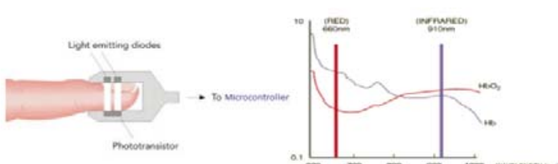
In the proposed system, the PMS is designed to measure and transmit biomedical signals to a controller unit. The most commonly measured vital signs include heart rate, electrocardiogram, blood oxygen saturation (SpO2), and body temperature through the deployment of various on-body sensors. Measurements of these parameters can be implemented using manifold objects such as bed, chair, clothing and other devices.

The communication flow as shown in Figure-1 concerns three sundry units, namely, the Sensor and a control unit for measuring health parameters, communication unit, and cloud monitoring unit. These units are connected wirelessly using a suitable communication protocol such as Bluetooth, ZigBee or wireless LAN. The four biomedical sensors are the one which senses the various parameters from the patient's body and those are transmitted for further evaluation.

3. SENSOR AND CONTROL UNIT

A. Pulse oximeter sensor

Oxygen supply is crucial for patients suffering from respiratory disorders. So to address this challenge and to facilitate the diagnosis, we propose a system that could use pulse oximeter readings to automate oxygen supply [2]. Pulse oximetry is a procedure used to determine oxygen saturation in blood, which is measured non-intrusively using the stated sensor [1]. The principle behind the pulse oximetry technique is, light absorption characteristics of haemoglobin. Oxygenated haemoglobin absorbs more infrared light (850-1000 nm) and allows more red light to pass through [2]. Deoxygenated haemoglobin absorbs more red light (600-750 nm) and allows more infrared light to pass through. Oxygen supply is a crucial need for patients with respiratory disorders. Hence a system is proposed to control oxygen supply from the acquired values [3]. Figure-2 shows measurement of SpO_2 from fingertip with its values and absorptive characteristics of haemoglobin.



Oxygen saturation	Risk level
Above 95%	Normal level
Less than 85%	Attention required
Less than 65%	Impaired mental function on average
Less than 55%	Loss of consciousness on average

Figure-2. Pulse oximetry measurement and nominal levels.

Pulse oximeter is essential when patient's blood oxygen levels requires monitoring in situations like anaesthesia practice in operations, emergency cases, intensive care units and recovery in hospital wards. It can also be used to automate oxygen supply for pilots in high altitude planes.

B. ECG sensor

Electrocardiography (ECG) is the recording of the electrical activity of the heart over a period of time, as detected by electrodes attached to the surface of the skin. It picks up electrical impulses generated by the polarization and depolarization of cardiac tissue and translates into a waveform [4]. The waveform shown in Figure-3 is then used to measure the rate and regularity of heart rates, as well as the size and position of the chambers, the presence of any damage to the heart, and the effects of drugs or devices used to regulate the heart, such as a pacemaker [5]. This analog signal obtained from the electrodes is sampled every 1.03 μs time interval to convert it into digital.

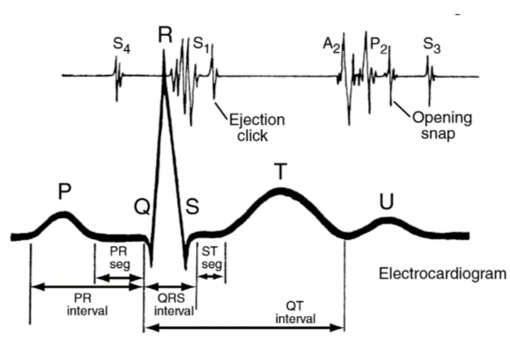


Figure-3. PQRST wave with electrical signal variation.

C. Heart rate sensor

Heart rate sensor is designed to give digital output of heat rate when a finger is placed on it. When the heart rate detector is working, the rate LED flashes in unison with each heart rate [5], [7]. 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 at each pulse [6].

D. Temperature sensor

Body temperature is an essential parameter for patients with The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in °C). The sensor output is in terms of millivolts typically 10mV/ °C, using which the temperature of the subject can be calculated [8]. By varying the resistance of sensor, its sensitivity is calibrated. Human body temperature range is shown in the Figure-4.

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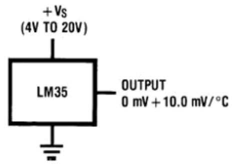

Remarks	Temperature
Normal	37 ºC
Hypothermia	Below 35 ºC
Hyperthermia	Above 38 ºC

Figure-4. LM35 sensor and body temperature range.

The obtained parameters from these sensors are processed through the communication unit.

4. COMMUNICATION UNIT

Depending on the amount of sensor data, the bit rate and the frequency band are decided. The proposed model uses numerical information which reduces bandwidth usage and hence power requirements. The 6LoWPAN has been considered as the most suitable technology for supporting mobility in sensor networks due to their low power and low data rate characteristics.

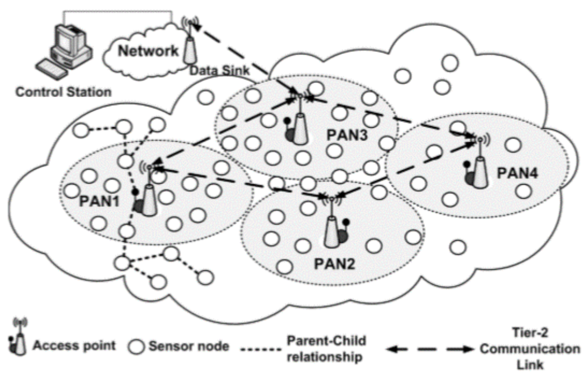

Figure-5. Cluster tree topology in ZigBee.

This protocol stack is implemented on top of the IEEE 802.15.4 [11]. A cost effective sensor network with low power consumption was developed using IEEE 802.15.4 standard to identify the monitoring device. ZigBee protocol states Low Rate Wireless Personal Area Network (LR-WPAN) operating in beacon-enabled mode with Cluster tree topology model [14], in which beacons are periodically sent by a central device, called the PAN Coordinator, to synchronize nodes that are associated with it. The ZigBee Network Layer provides appropriate routing mechanisms for multi-hop message transmission along a WSN.

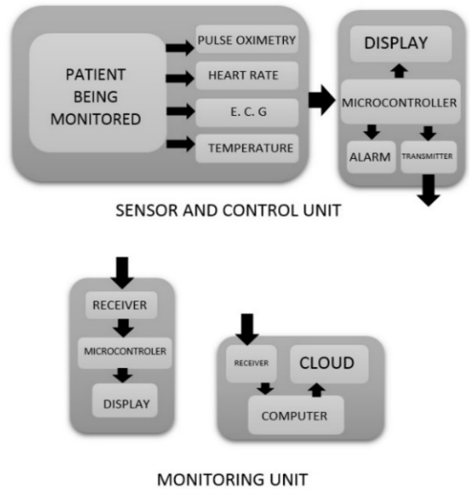

Figure-6. System flow with implemented units.

The system flow diagram with all implemented units is shown in Figure-6. Through wireless communication, multiple health parameters of the patient are monitored by using the monitoring unit.

5. MONITORING UNIT

Continuous observations of the patient's physiological parameters are carried out for the purpose of diagnosis. A patient monitor may alert caregivers about potentially life-threatening event of the patient. *Cloud monitoring* is done using these two programming languages viz,

PHP is a server-side scripting language designed for web development but also used as a general-purpose programming language. PHP incorporates live update of data to the server [9].

NET is an integral part of many applications running on Windows and provides common functionality for those applications to run. SQL is used for managing data held in a relational database management system [10]. An application was developed to show the patient health parameters and their status in real-time.

A care taker is given a *portable monitoring device* that receives data from the control unit. It displays current status of a patient and also intimates patient's critical condition by giving an alarm or message. The proposed system is based on the RTM WiSe architecture which is further discussed.

6. RTM WiSe ARCHITECTURE

The proposed system consists of four main layers; the application layer, middleware layer, the network layer, and the acquisition layer. Each layer is classified into various sub-layers to address the issues in the prototype as shown in Figure-7.

Acquisition layer: Internet of Things (IoT) is deployed with multiple biomedical sensors, each of which is an information source [16]. These sensors capture different health parameters in real time and then processed

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using a middleware, typically a microcontroller. The processed information is sent to monitoring device at a particular frequency and keeps on updating.

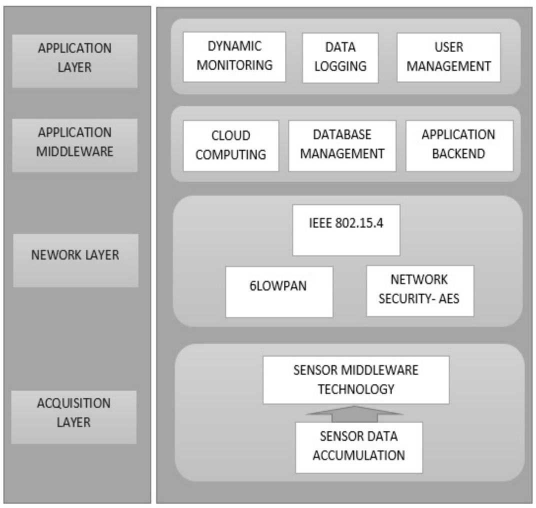

Figure-7. RTM-WiSe architecture showing various layers.

Network layer: The update process is carried out by the network layer. A routing algorithm routes the packets in a shortest path to achieve real-time communication. 6LoWPAN based on IEEE 802.15.4 is used to minimize the energy consumption and to incorporate the system to internet of things [15]. It is obvious that securing a wireless network is a challenging task. ZigBee standard applies the Advanced Encryption Standard (AES) with 128 bits symmetric key for securing wireless transmissions. Due to the resource constrains in sensor networks symmetric key cryptographic algorithm is used. It is three to four orders of magnitude faster to compute compared to a public key cryptographic algorithm.

Application middleware layer: This layer implements cloud computing and database management of the collected data. The IoT typically create huge amount of data [16]. The data have to be stored for keen monitoring and actuation [15]. This promotes the vision of healthcare to anyone, anytime, and anywhere by removing location, time and other restraints whereas increasing both the coverage and the quality of healthcare services.

Application layer: The application layer defines the capabilities of the proposed system such as dynamic monitoring and logging of the received data. User management helps in serving the system for monitoring a number of users [16]. The logged information of the users is used for further evaluation.

7. RESULT

The designed prototype was tested with few persons with varying health. The patient reported with hyperthermia (fever) is monitored in real-time and the output is produced. The output of the application and a live updating URL through cloud for dynamic monitoring is shown in Figure-8.

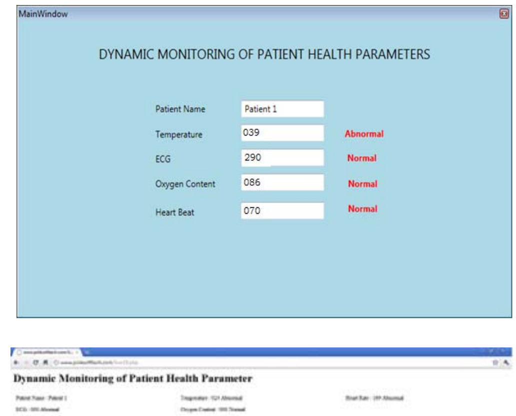

Figure-8. Output of monitoring section with live updates.

The monitoring section in a hospital has a user interface to log and view the patient details with their health parameters. The same data relayed to a cloud server and viewed remotely using an URL. The time taken for updating the measured data through ZigBee is 0.413 ns. Overall, the advantage of the proposed system is being discussed in the conclusion.

8. CONCLUSIONS

The RTM WiSe architecture of IoT has been proposed. Based on this architecture, the energy consumption, the cost, the consumption of time, and the security accuracy were improved. The proposed system successfully and simultaneously measures Oxygen saturation, Heart rate, ECG, and temperature. With the implementation of cloud computing, this system offers support for large scale connectivity as well as incorporation with information systems. This improves accessibility to clinical services, enhancing medical attention and promises access to medical information, anywhere and anytime securely. It is well suited for long-term health monitoring. The achieved results reveal the cogency of proposed system for health monitoring of patients.

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