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Efficient Health Care Monitoring and Emergency Management System using IoT

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ABSTRACT

IoT have materialized, because of the advent in information and communication technologies. The use of IoT concept brought the ease of use for the clinicians and patients since it could be applied to a variety of medical functionalities such as health monitoring and health management. Sensors implanted in patients and communication of sensor data using IEEE 802.15.4, GPRS/GSMandHTTP is foundation technologies of IoT deployments in the healthcare systems. In this paper, a patient's heart beat and finger moisture levels are sensed through appropriate sensors and planned to transmit these data to a physician at a remote location using GPRS/GSM. The physician could provide emergency medication suggestion through his mobile phone. Also, it is proposed to make these data available in cloud and health care (historical analysis) is monitored from cloud. As cloud could support in managing increasing volume of health data in medical engineering, professionally share the information across health care systems, bring down operational and management costs and could provide reasonable health care services, in this paper, Intel Galileo gen 2 which plays the role of Iot agent to deploy the medical data in to cloud is proposed and implemented. The response time is found to be less and hence the performance of the proposed system is improved with the existing remote health monitoring system.

Keywords: health care systems; IoT; emergency;monitoring; management; sensor.

1. INTRODUCTION

The objects, animals or people are equipped with unique identifiers in IoT paradigm. Electronic devices are used to capture and monitor the data in IoT and are linked with public or private cloud. The data could be transmitted over a network without human or computer intervention. "Thing", in this paper is a person with a finger moisture sensor and heart beat monitoring sensor implant. Along with the unit a GPS, cellular connection, and Wi-Fi chip work together to measure moisture activity levels, heart beat levels.

People affected with Sjögren's syndrome (causes dry eyes and mouth; a type of autoimmune disease) [1] are also associated with Peripheral neuropathy, this causes loss of sensation in fingers, hands, arms, toes, feet, and legs and Raynaud's phenomenon [2] where in the extremities of the body, usually the fingers and toes, change colour and may become painful, usually due to exposure to the cold. Hence in this paper, monitoring a patient with above disease is carried out with the finger moisture sensor implant on the patient. In addition heart beat monitoring is also proposed to be monitored.

A sensor-equipped "thing", in this paper possesses three qualities. It is aware; it is able to sense and collect data about finger moisture and heart rate. It is autonomous. The data collected is communicated to another device (mobile phone through GSM/GPRS) automatically or when certain conditions are met or central location (public cloud). Hence health care monitoring is possible. Lastly, it is actionable. If patient's

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heart beat rate levels are at a dangerous level, it will automatically trigger an alert in the mobile phone and initiate clinician action. Hence appropriate health care management is possible.

Such monitoring and management, particularly for individuals with chronic diseases, could not only recover health status, but also could lesser costs, facilitating prior intervention before a condition becomes more severe. Information collected from IoT devices will have great advantage for analytical purposes, helping the physicians to better understand disease and treatment as well as manage the health of populations. These types of monitoring systems demonstrate how all things such as patients, physicians, emergency services, and healthcare facilities can be connected and used to extract the important value from available, real-time data.

This paper is organized as follows: Section II describes the recent trends in health care systems in IoT. Section III details the proposed system. Section IV details the materials and methods used for implementation. Section V describes the evaluation analysis. Section V concludes the paper.

2. STATE OF THE ART

A novel cloud ecosystem architecture featuring an overall lightweight data access control model, enabling data access policies based on location information of service consumer devices is proposed [1]. The architecture is applied in the sensitive healthcare domain, which itself comprises multiple parties with complex data access privileges. Cloud computing [2] can help easily manage the growing volume of medical data, efficiently share information between health care systems and optimize the organization’s operational cost. Cloud computing can help the health care industry align its IT needs based on a real time requirement, rather than on a calculated guess.

A pulse oximeter prototype is introduced in a paper [3] which is designed for mobile healthcare. In this prototype, a reflection pulse oximeter is embedded into the back cover of a smart handheld device to offer the convenient measurement of both heart rate and estimation of arterial oxygen saturation for mobile applications.

Pervasive healthcare [4], which provides healthcare services to individuals anytime-anywhere, has got a major focus in the research fraternity. A paper survey [5] the advances in IoT-based health care technologies and reviews the state-of-the-art network architectures/platforms, applications, and trends in IoT-based health care solutions. Connected devices [6] are existing concept.

The IoT enables the connection and communication from anywhere to anywhere and permits analytics to replace the human decision-maker. There are many devices available for health care. Within the next two years, there will be 80 million wearable health devices [6]. Currently there are large number of personal use of fitness trackers such as FitBit and smart watches. The next generation of these devices will be able to do more than just track steps and calories.

Currently, there are no standards or regulations to govern about the information collected via the IoT [6]. A guide is prepared by the National Institute of Standards and Technology to secure connected medical devices. Empowering health monitors [7] and patient devices with Internet capabilities are available; however there is a lack in service intelligence in generic m-Health scenarios.

Latest advances in miniaturized sensors, low-power electronics and wireless communications [8] have facilitated the development of Body Sensor Networks (BSNs). These networks consist of intelligent communicating nodes which are committed to healthcare monitoring to detect and correct health problems. A paper [9] attempts to expansively evaluate the contemporary research and development on wearable biosensor systems for health monitoring.

The typical daily cost for single in patients in hospitals was over $1,700 in 2013, according to the Kaiser Family Foundation [10]. Remote monitoring products such as the BodyGuardian provide the healthcare advantages such as the option to move patients to their home and retain monitoring of their status by doctors and nurses. A paper [11] proposes an original, IoT-aware, smart architecture for automatic monitoring and tracking of patients, personnel, and biomedical devices within medical institutes.

Fastest to espouse the Internet of Things is the Healthcare industry [12]. The motive for this inclination is that incorporating IoT features into medical devices significantly advances the quality and efficacies of service, bringing particularly high value for the elderly, patients with chronic conditions, and those have the need of constant supervision. IoT-related healthcare systems nowadays are based on the fundamental definition of the IoT as a network of devices that connect directly with each other to capture and share vital data through a secure service layer (SSL) [13] that connects to a central command and control server in the cloud.

3. PROPOSED SYSTEM

We mainly introduce the design of a heterogeneous IEEE 802.15.4 based personal health device monitoring system which consists of different Health Monitoring sensors, such as finger humidity and heart beat rate sensors. The Health Monitoring sensors are touched by human to sample the physiological signals of the people.

Numerous patients could be assisted from constant ambulatory monitoring as a part of a diagnostic process, finest maintenance of a chronic circumstance or during supervised healing from an acute event or surgical practice. Even there are situation that the patients should be monitored continuously for certain parameters. The sensors connected require different application and different data transfer protocol from one another. Hence in this paper IEEE 802.15.4 technology is used for data transferring. IEEE 802.15.4 protocols are intended for use in embedded applications requiring low data rates and low power consumption.

Proposed IoT system architecture is shown in figure 1. body sensors such as humidity sensor implanted in the finger and heart beat sensors are connected with IoT agent. The sensed information could be deployed

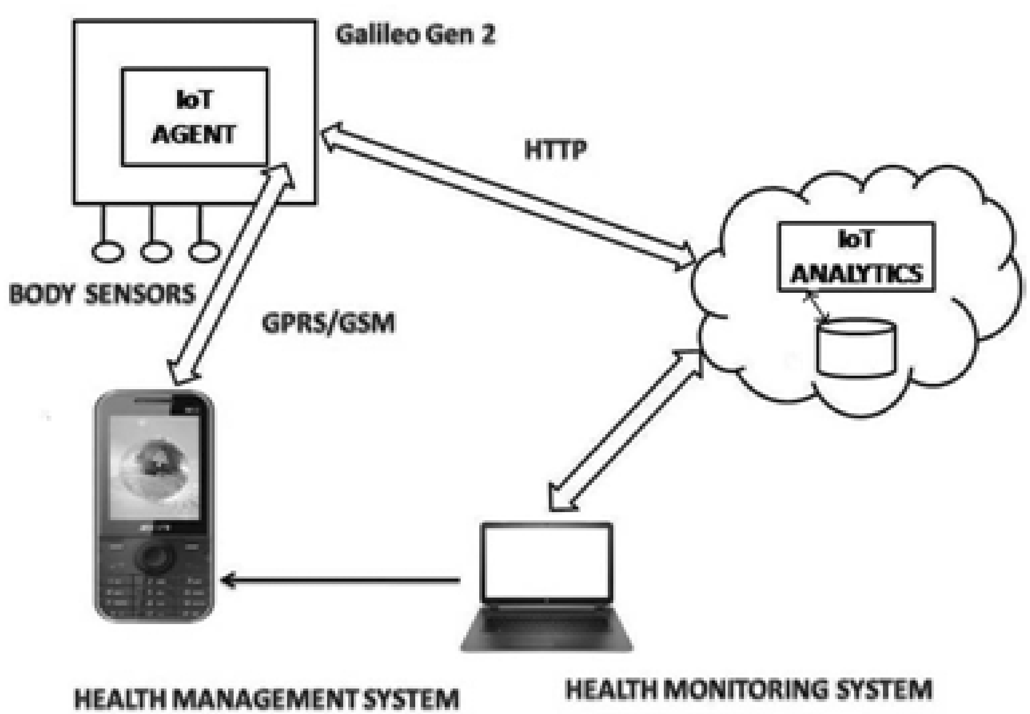

Figure 1: Proposed IoT Architecture

in to cloud for further historical analysis of health parameters of a particular patient. The monitoring system could collect health data from cloud with appropriate gateway. The mobile phone of the physician could be directly connected with IoT agent using GPIO pins. The physician could provide support in case of emergency situation of patients, i.e., if heart beat rate exceeds the recommended value, an alert could be generated from the physician for proper medication suggestions. Alternatively the health monitoring system could also be connected with the mobile phone.

The system proposed, deliver intelligence where needed to acquire and deliver health data securely. Billions of such intelligent devices could share data and securely supporting legacy and new environments through the proposed system. The system provides connectivity from digital sensor device to cloud to deliver end to end customer (patient – physician) value.

4. MATERIALS AND METHODS

As, Intel Galileo is now officially registered device under IBM Internet of Things Foundation (IoT Foundation), it is been selected for implementation. Arduino programming for Intel Galileo Gen2 is done to record the sensor values. Sensors are used for health care data collection. Interfacing with physical world such as digital sensors, GPRS/GSM, and I2C is possible with Intel Galileo Gen2, and hence it is chosen for implementation. Fig 2 and 3 shows the heart beat sensor and moisture sensor in the proposed work. Intel Galileo Gen2 also offers the connectivity of sensors through cloud with the Wi-Fi support through miniPCIe slot available; leading to IoT based health care system. Intel provides end to end IoT Solutions so that one could quickly connect, manage, and protect the digital sensors. Figure 4 shows the finger moisture deployed in "Thingspeak" cloud, and it shows the recording of moisture value at various time intervals.

ATWIN Quad-band GPRS/GSM [17] shield has PCB etched antenna, so no need for external antenna. ATWIN Quad-band GPRS/GSM shield is an ultra compact and high quality wireless module base on Infineon UCL2 platform with industry-standard interface. This is a SMT package with small dimension, low power consumption, quad-band (AT139) and dual-band (AT139D) GSM/GPRS module. It can provide with voice, SMS, Fax, data applications for customers. Figure 5 shows this.

- Rx of hardware serial port is connected to Galileo's D0.
- Tx of hardware serial port is connected to Galileo's D1.

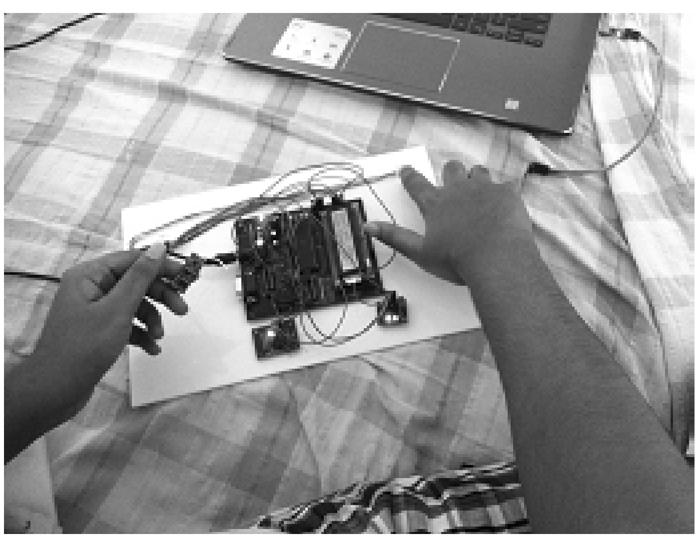

Figure 2: Heart beat sensor with micr controller and IEEE 802.15.4 sender and receiver

- 5V of hardware serial port is connected to Galileo's 5V.
- GND of hardware serial port is connected to Galileo's GND.

Insert an unlocked SIM card. The SIM is a mini-SIM or 2FF size. Attach the shield to the Galileo. There is no extra wiring necessary. Set the Serial port select jumpers to the Hardware Serial position:

- Set J1 so that Rx is connected to MTx.
- Set J2 so that Tx is connected to MRx.

Figure 6 shows the SIM card inserted into Intel Galileo.

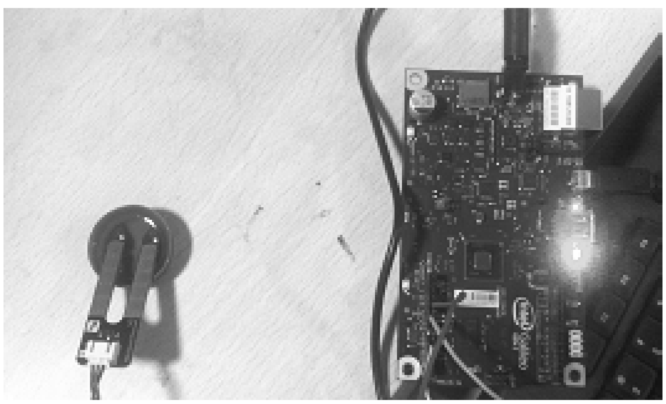

Figure 3: Moisture sensor with Intel Galileo Gen2

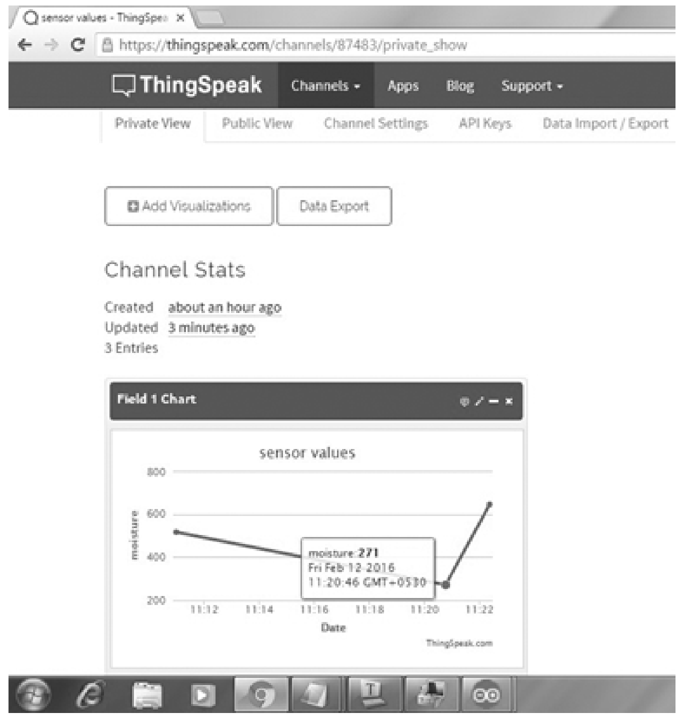

Figure 4: Finger moisture deployment in Thingspeak cloud

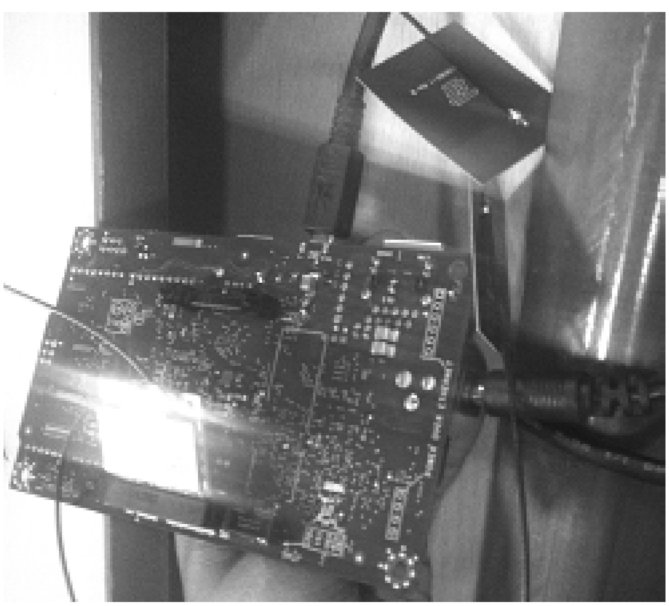

Figure 5: SMT package inserted into Intel Galileo with PCB antenna

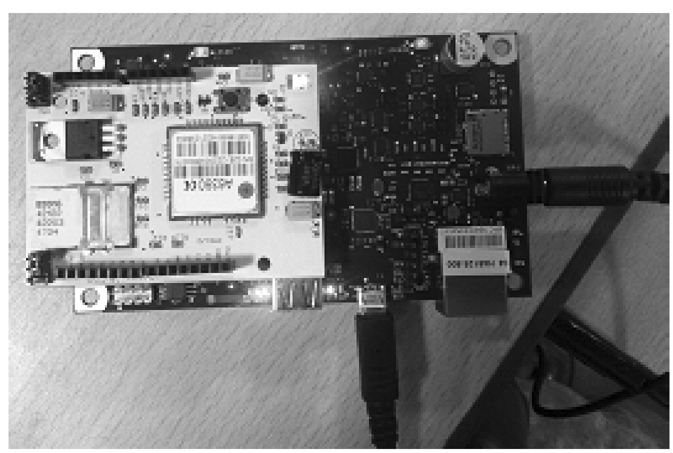

Figure 6: SIM Card inserted to Galileo Gen2

5. RESULTS DISCUSSION

The heart beat rate monitoring is accomplished by making the person (whose heart rate to be monitored) to press the sensor, and it starts transmitting heart beat data and this is deployed in Thingspeak cloud through IoT agent as shown in figure 4. From the cloud the information goes to the monitoring interface which is shown in figure 7 and 8. From the interface the mobile phone could be connected. Alternatively the IoT agent is connected to the mobile phone with SMT package and SIM card inserted to it.

The alert system is based on threshold calculated as shown in Figure 9. The proposed system is designed to send alert message instantly, once arrhythmia is detected. The system has also the ability to notify the conditions of tachycardia and bradycardia. The alert messages are generated at mobile phone as shown in figure 10. Extracted physiological parameters give the alert signals after comparison with assigned threshold [16] values. These alert signals indicate aberration such as arrhythmia. The proposed system contains adaptive alert system which generates alerts to notify the concerned physician in case of emergency.

The following AT(attention) commands are used to send a SMS to physician mobile in Text mode

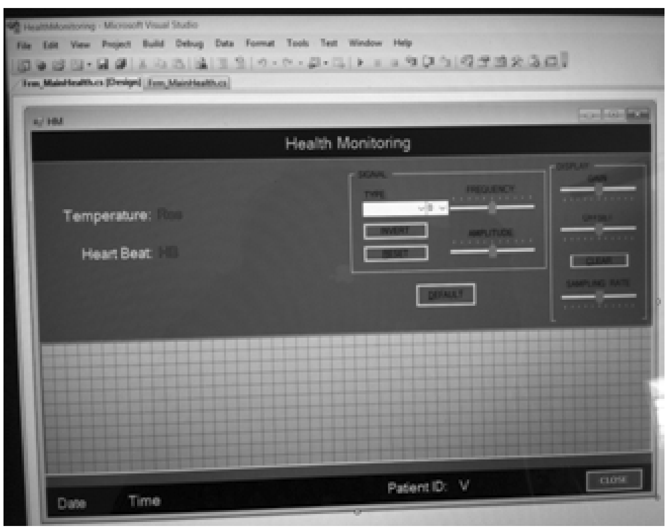

Figure 7: Health monitoring of Interface

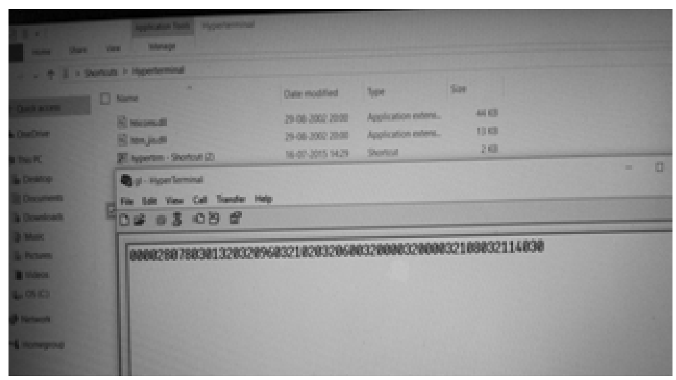

Figure 8: Application Interface for real time monitoring of Heart beat

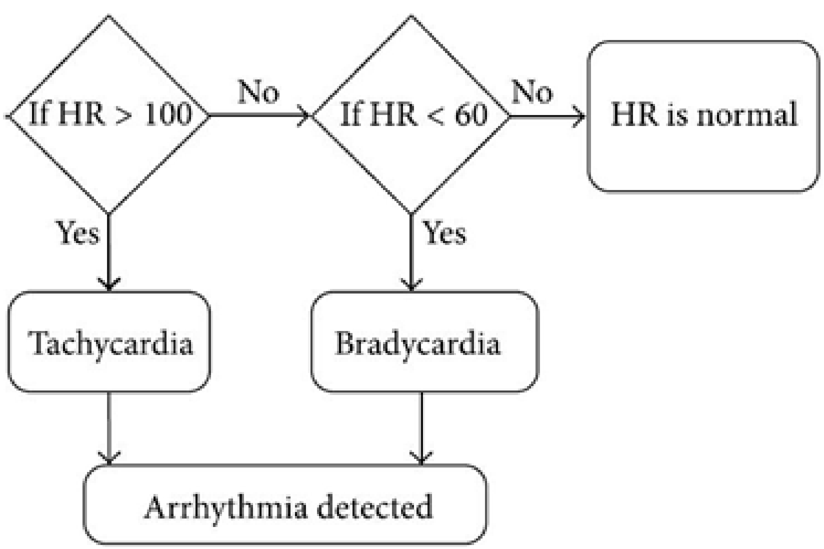

Figure 9: Flow chart for alert

"AT + CMGF = 1\r"

To add the receiver (physician) no.

"AT + CMGS =\" 09698433804\""

```
void SendTextMessage()
{
Serial1.print("AT+CMGF=1\r"); //Because we want to send the SMS in text mode
delay(1000);
Serial1.println("AT+CMGS=\"+917829374149\"");
delay(1000);
Serial1.println("Hello from Galileo?");
delay(1000);
Serial1.println((char)26); //the ASCII code of the ctrl+z is 26 (0x1A)
delay(1000);
Serial1.println();
}
void ReceiveTextMessage()
{
Serial1.println("AT+CMGF=1"); //Because we want to receive the SMS in text mode
delay(1000);
Serial1.println("AT+CPMS=\"SM\""); // read first SMS
delay(1000);
Serial1.println("AT+CMGL=\"ALL\""); // show message
}
```

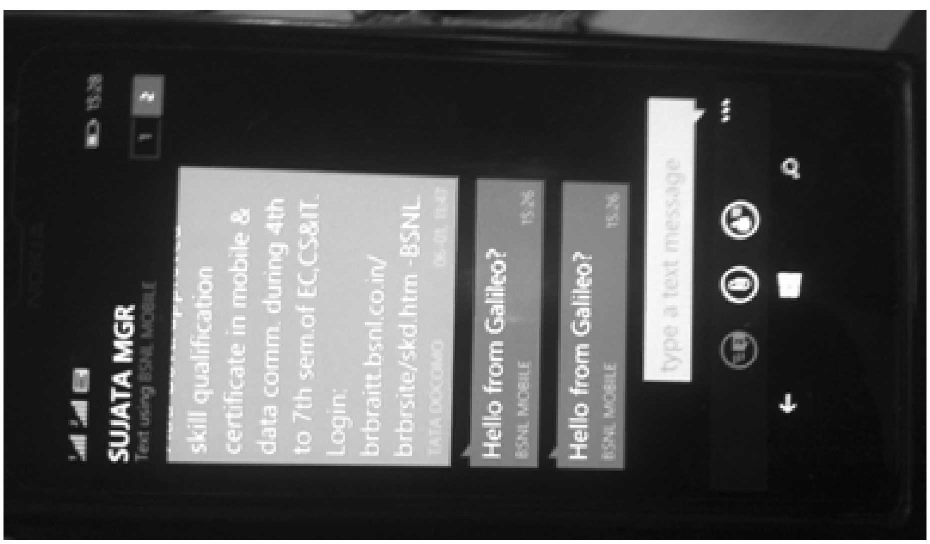

Figure 10: Alarming interface of remote patient monitoring system.

Table 1
Threshold values foe alert

Sinus rhythm type	*Threshold value of heart rate)*
Normal	60 ≤ HR ≤ 100 (beats/minute)
Tachycardia	HR ≥ 100 (beats/minute)
Bradycardia	HR ≤ 60 (beats/minute)
Sinus rhythm type	*Threshold value of heart rate)*
Normal	60 ≤ HR ≤ 100 (beats/minute)
Tachycardia	HR ≥ 100 (beats/minute)
Bradycardia	HR ≤ 60 (beats/minute)

Table 2
Average Data Transmission Time

Alert for	*Average time b/w sending andreceiving alert in Wi-Fi (H:M:S)*	*Average time b/w sending andreceiving alert in 3G network (H:M:S)*	*Average time b/w sending andreceiving alert in proposed IoT system (H:M:S)*
Tachycardia	00:00:29	00:00:58	00:00:25
Bradycardia	00:00:30	00:00:59	00:00:28

Note: the value for each type of alert is the average value of 20 alerts.

Table I shows the threshold values for the alert for heart beat rate. Table II shows the recordings of the heart beat alerts in the proposed IoT based health monitoring system. It is compared with the existing system [16], and it is found to provide the alert with lesser response time, and hence the performance of the proposed system is improved as for as the heart beat rate monitoring is concerned.

6. CONCLUSION

Health monitoring parameters such as finger humidity and heart beat rates are considered in this paper. The parameters are monitored through "Thingspeak" cloud using IoT agent. The health parameters management is achieved by means of alert messages through mobile phones using GSM/GPRS connection possibilities of the IoT agent. The monitoring (raising alert message when the stipulated threshold reaches) response times are compared with previous methodologies and found to be improved.

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