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Implementation of PHM System using IoT and Raspberry Pi

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Abstract: IoT is an emerging technology, which permits devices and people correlated in an organized manner. In the era of IoT, the body sensor network technology is a part of it and has been rapidly increasing in the field of medical scope. In the medical area the applications like real time monitoring, patient information management and healthcare management are presently receiving a good scope in the market. Many patients are dying because of the unavailability of the doctor in correct time. To surmount this problem patients are adhered with tiny sensors so that the patient information can be remotely monitored by the doctor. The patient health monitoring system creates a remote interaction between the patient and doctor. The tiny sensors like temperature, Heartbeat, Blood pressure are arranged in a manner to the patients to form an efficient Body sensor network. The sensors that adhere to the patient's body are interfaced to the Raspberry Pi 3, which is used for monitoring the real time data of the patients and provide timely details to the doctor in the form of the web page. The doctor sitting in the cabin can monitor the values from the sensors in the web page and can respond in correct time to the patient health conditions. This patient health monitoring system delivers an increasing demand and it is very economical and offer real time information and efficient compared with the present existing models.

Keywords: Body sensor network, IoT, Patient health monitoring system, Raspberry Pi 3, Tiny sensors.

1. INTRODUCTION

In the 21st century, IoT has become the most persuasive technology. In the modern world every device became part of the internet due to their computation and communication capabilities with the advancements made in IoT. In the era of IoT, more devices can be accessed and they get connected anytime based upon the network and will extend their services to real time applications. In future, IoT can uniquely create a trend on the devices which are having computation abilities [1]. The generated data from the IoT devices is further analyzed and decisions are made. Many advancements and new methodologies go up day by day on the basis of Internet of Things. IoT has numerous enhancements in the domains like healthcare, Smart environment, Smart Home, Smart industries.

IoT extends its ease in the domain of the health care system, the Body sensor network is the most imperative technology in the field of health care systems [2]. Many enhancements are held in the development to the IoT in

the field of health care systems. Some of the advancements made are diagnostics, Remote monitoring medical parameters, smart hospital services. The face of healthcare is transformed by implementing the way personnel, applications, devices communicate with each other with the support of IoT [3]. With the help of SMS facility doctor will be notified [4].

Health is the most vital role in every human being. Even though people are having all the luxuries in their lives, but if their health is not in good condition they cannot enrich their lives. Many patients are dying because they are not receiving proper medication in time. So to control the patients death rate the patient health monitoring system is implemented [5]. The health services that are provided to the patients are not economical and are not affordable by all the classes of people. Generally in a hospital all the patients are kept in one room for treatment but, this may cause disturbance to other patients. The Doctor may be busy with dealing with the critical patient and may not extend the service to other patients. In traditional remote patient monitoring the patients are equipped with Personal digital assistants and the doctors are equipped with personal computers. This system is costly, delay in sending data, stealing of patients health data may take place [6]. With this system proper medication can be provided and patient's life can be saved. The ultimate objective of the patient health care system is to provide efficient health care facilities and to bring the medical costs down. In the field of medical applications, IoT enables to contribute better patient care and reduce health care costs [7]. IoT devices in the field of health care can essentially accomplish the operations like collect, monitor, evaluate and intimate the doctors about the patient's health parameters [8]. In the patient's health care system, the system continuously monitors the patient Blood Pressure, Temperature, Heartbeat and performs essential evaluations and notify the doctor with periodic Updation [9]. The Patient health monitoring system is classified into three segments like patient, central server, doctor [10].

2. LITERATURE SURVEY

The urge for the patient's health care management system is it can eliminate two dominant obstructions. First obstruction is that the doctor has to be on the site of the hospital for a long time. Second obstruction is that the patients are remained admitted in the hospitals for small health problems and may feel uncomfortable to stay in the hospital [11]. Thus the implementation of this system more no of patients can be supervised and better services can be contributed. The wearable tiny sensors are easily integrated with the human body in the patient health monitoring system and so that it can sense the physical parameters of the patient's body [12]. The temperature sensor, BP sensor, Heartbeat sensor is low cost and are having predominant circumstances in the patient health care management system. The BP, heartbeat, the temperature sensor is familiar and frequently used because every patient's health will primarily depend on these parameters. In general, every doctor is confined to support only one patient in real time, but by this system one doctor can monitor realtime details of many people. In comparison with the traditional approach to health care, the modern patient health management system will offer better health services 24x7 in any efficient manner [13] - [15]. In this developed patient health care management system, frequent visit of doctor by the patient's is completely eliminated.

The patient's health care management system has many challenging goals in the area of security. Many enhancements are ongoing for the implementations of the patient's health care management system. The data privacy is the considered to be the dominant aspect. The data of the patient must be secured and must enable them from outside network attacks. Data integrity is another issue because the patient's parameters are continuously transmitted to the central server there may be chances where data may be lost due to poor communication. With the employment of IoT in health care systems, the devices are connected to patient, collect real time data by a central server and perform analytics on the data and provide the data to the real world in a user friendly manner [16], [17]. Authentication is another significant issue because if no authentication is provided, then any person

can see the health parameters of the patient periodically [18]. Traditional remote health care system operates in the low speed processor and they are not efficient and cannot provide computations. As it operates on low memory, sufficient amount of data cannot be held by the IoT device.

In any system the power saving is the utmost challenge because the wearable sensors must not consume more power [19]. A Certain power saving option must be enabled so as to reduce the power consumption. Employment of variable wired and wireless communication technologies like ZigBee, GSM, Wi-Fi, Ethernet, Bluetooth can be integrated into the Patient health care management system [20] - [21]. The Wearable sensors are limited by number because of the unavailability of interfacing ports in the central server Raspberry Pi 3. Appropriate technology is chosen for the efficient utilization of the patient's health care management system. In real world applications the Wearable sensors are mobile and must be easily integrated with the services provided by the IoT [22].

3. HARDWARE USED FOR SYSTEM IMPLEMENTATION

Figure 1 represents the block diagram of the patient health monitoring system and the detailed description is discussed below.

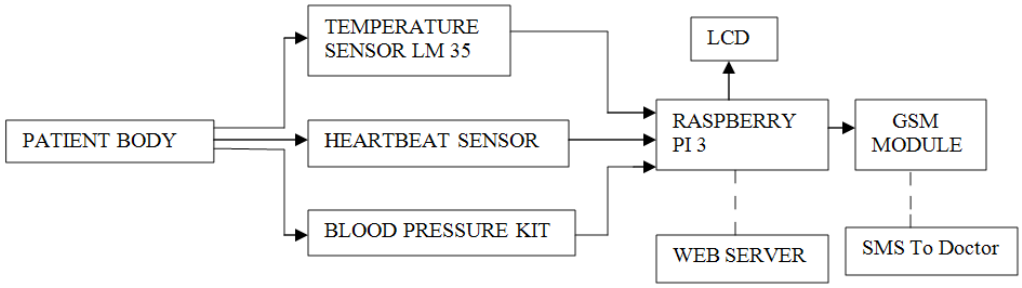

Figure 1: Block Diagram of patient health monitoring system

A. **Blood Pressure kit:** The BP kit works on UART and operates at a desired voltage of 5 V. It is capable of functioning on 8 bit data. The BP kit has three terminals the supply, ground, UART output. As the blood circulates upon on the walls of the blood vessels then there exists a pressure which is termed as Blood pressure. Whenever the heart beats Blood pressure shifts between Systolic and diastolic pressure. It is measured with the sphygmomanometer and the units are mm Hg. There exists various classifications in the Blood pressure for adults, they are Hypertension, Desired, prehypertension, Stage-1 Hypertension, Stage-2 hypertension, hypertensive critics. The classification of blood pressure shown in Figure 2 is based on the Systolic and Diastolic values in adults. High Blood pressure can cause many health relevant problems like heart attacks.

Category	Systolic(mm Hg)	Diastolic(mm Hg)
Hypotension	<90	<60
Desired	90-119	60-79
Prehypertension	120-139	80-89
Stage 1 Hypertension	140-159	90-99
Stage 2 Hypertension	160-179	100-109
Hypertensive Crisis	>180	>110

Figure 2: Classification of Blood pressure in Adults

B. **LM 35:** The LM 35 shown in Figure 3 is a favored temperature sensor. It is a three terminal device. It functions on operating voltage ranging from 4-20 V. It is low cost and less current drain. The value

measured by the LM 35 is linear with the Celsius temperature reading. It eliminates the problem of oxidation. It works on the fundamental of thermocouple. It has a desired accuracy of +/- 0.4°C. It can measure a set of values ranging from –55°C to +150°C.

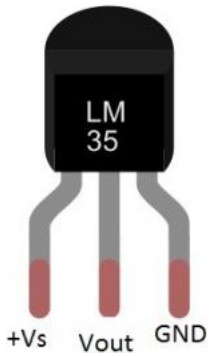

Figure 3: Pin configuration of LM 35

C. **HEARTBEAT SENSOR:** The heartbeat sensor is used to poll the number of times the heart beats per minute. The heartbeat sensor is generally adhered to the finger or the ear lobe. The heart beat reflects the patient's health conditions. The desired heart beats for a person who is at rest in 60-100 per minute. Adults have a desired heart beat of 90 beats per minute. For sports people their pulse rate is low compared with others. The heart beat sensor comprises of IR led and LDR both combined together to form a clip like structure. The Figure 4 shows the heart beat of different category of people. The Figure 5 shows the heartbeat sensor module.

Age	Range of Heart Rate at Rest (in beats per minute)
0 to 1 year	100 to 160
1 to 10 years	60 to 140
Over 10 to adults	60 to 100
Young Athletes	40-60

Figure 4: Heart beat classification for different Age groups

Figure 5: Heartbeat sensor module

D. **RASPBERRY PI 3:** The Raspberry Pi 3 which is shown in Figure 6 is a low cost, efficient processor. It works on the operating voltage of 5 V. It can facilitate the user with all the features that are provided in the personal computer. The Raspberry Pi 3 acts as a central server controlling all the data. The Raspberry Pi3 is programmed using Python programming language. All the information from sensors attached to the body are interfaced to the Rasppberry Pi to achieve high computations and efficient data communication.

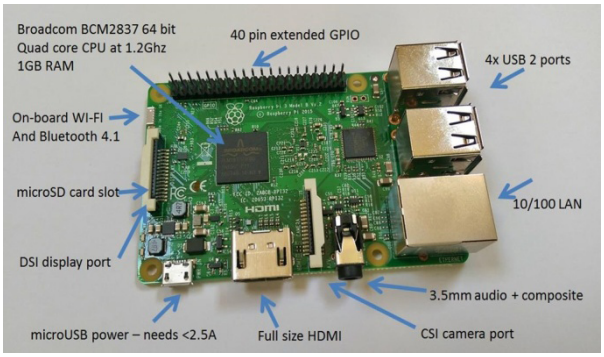

Figure 6: Hardware of Raspberry Pi 3

E. LCD: Liquid crystal display is a type of display used in digital watches and many portable computers. LCD shown in Figure 7 used to display the measured data. A 16 x 2 Alphanumeric Display which means on this display we can display two lines with a maximum of 16 characters in one line.

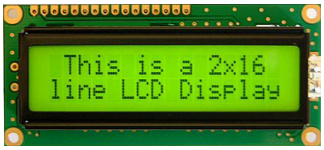

Figure 7: 16 x 2 LCD module

F.GSM MODULE: To organize communication between processing system like Raspberry Pi 3 and GSM system a GSM Module shown in Figure 8 is required. The GSM module is inbuilt integrated with a power supply and communication interfaces like RS232, USB. A SIM is required in the GSM module to maintain communication between users just like a mobile phone. IMEI number provided for unique identification for every GSM System.

Figure 8: GSM Module

4. IMPLEMENTATION METHODOLOGY

Health is one of the prime factors for every individual. In the implementation of the patient health monitoring system, the system consists of a wearable sensors like Heartbeat sensor, Temperature sensor, Blood pressure sensor. The Figure 9 represents the hardware of the developed system.

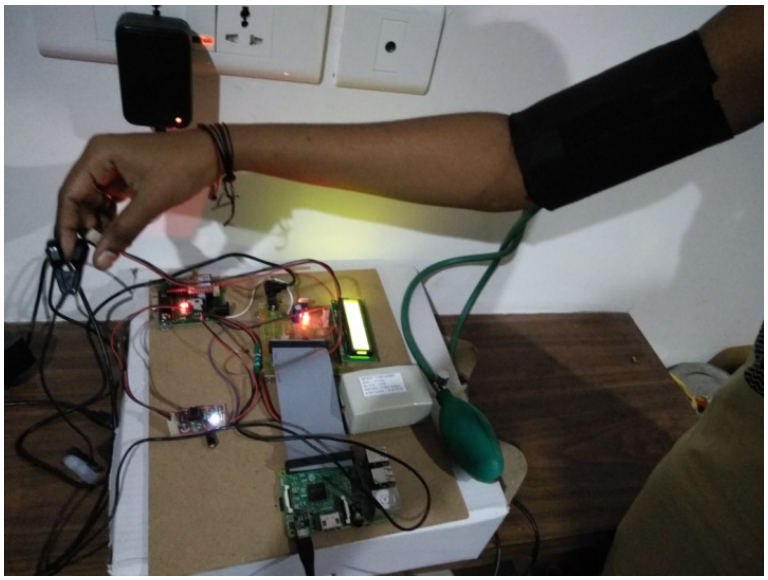

Figure 9: Hardware of the implemented system

This patient health monitoring system provides the detection of diseases at an early stage and proper medication is provided. To monitor the patient's body parameters the sensors have adhered to them. Every patient has a setup with the desired patient health monitoring system. All the sensors are interfaced to the Raspberry Pi 3. The temperature sensor LM 35 is used to measure the patient's body temperature and collect the data and transfer it to the Raspberry Pi 3. The patient's temperature parameters are continuously updated with the help of central server Raspberry Pi 3 to the database on the web server and the doctor can monitor the temperature of the patient's body in the web page. The temperature parameters of the body must be within some preferred limit. If the logged value is not in the favorable range, then the doctor will be notified in the form of SMS.

The heartbeat sensor analyzes the number of times the heartbeat and it is measured with the help of practical heartbeat sensors. The heartbeat sensor is attached to the finger of the patient and the data are continuously uploaded with the help of Raspberry Pi 3 into the database on the web server and the doctor can easily monitor the patient's details. If the doctor is not available with the monitoring system, doctor will receive a message if the heartbeat is not within the favorable range and immediate action can be taken place and patient life can be saved.

The Blood pressure measures the systolic and diastolic measurements of the patient. The Blood pressure of the patient is measured with the Sphygmomanometer in terms of mm Hg. The parameters of the patient's blood pressure are sent to the Raspberry Pi 3 and from there it uploads into the database on the web server. The doctor can monitor the blood pressure of the patients on the web page. If the blood pressure parameter of the patient is not in an accurate range, then doctor will receive an SMS and immediate medication is provided by the doctor. The patient health monitoring system provides the doctors with the patient's health parameters and it acts like a warning to the doctor about the patient's health. The developed system decreases health care cost, doctor to patient efficiency.

5. RESULTS

The patient's health parameters from the heartbeat sensor, temperature sensor, Blood pressure arranged at the patient is collected in the Raspberry Pi 3 and arranged in the database of the web server. The Figure 10 displays the updated values in the web page.

Hello Sandhya Welcome to Patient Health monitoring system

Goto Search

Page 1 of 2 Next

S.No	Temperature	BP	Heart Beat	Location	Date
1	97	124/80	71	Location	2017-01-21 19:19:12
2	97	140/90	66	Location	2017-01-21 19:18:21
3	97	124/80	68	Location	2017-01-21 19:17:30
4	97	124/80	79	Location	2017-01-21 19:16:38
5	97	118/82	60	Location	2017-01-21 19:15:43
6	97	110/75	66	Location	2017-01-20 18:51:47
7	97	110/75	64	Location	2017-01-20 18:51:04
8	97	110/75	63	Location	2017-01-20 18:50:20
9	97	110/75	70	Location	2017-01-20 18:49:38

Figure 10: Patient health parameters in the web page

The data is oraganized in the format of rows and columns in the web server. The columns depicts the temperature, Blood Pressure, Heartbeat, location and the respective time stamps. The rows depict the values from the sensors arranged at the patient. The doctor will remotely monitor the health parameters of the patient's in the web page and will take necessary medication steps in advance so as to eliminate the health problem.

The doctor will receive an emergency SMS, if the medical parameters of the patients are not in the safety scope. The Figure 11 shows the message received to the doctor when the temperature is abnormal. So by receiving the message the doctor can take care of the patient in advance.

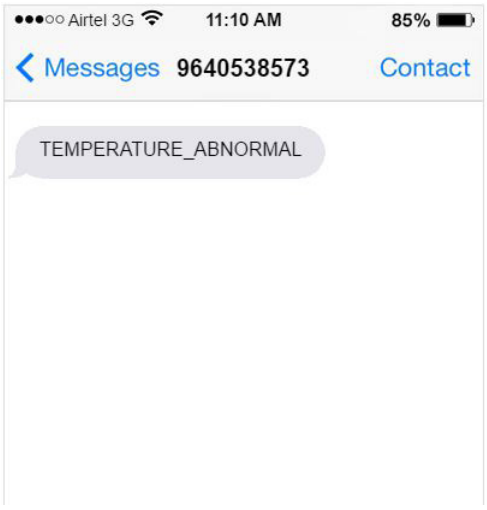

Figure 11: SMS Temperature is abnormal received by the doctor.

Figure 12 depicts the SMS received by the doctor when the heart beat is in an abnormal condition. The patients heartbeat may vary irrespectively, so by determining the threshold state of the heartbeat the doctor can treat the patient in advance with proper medication.

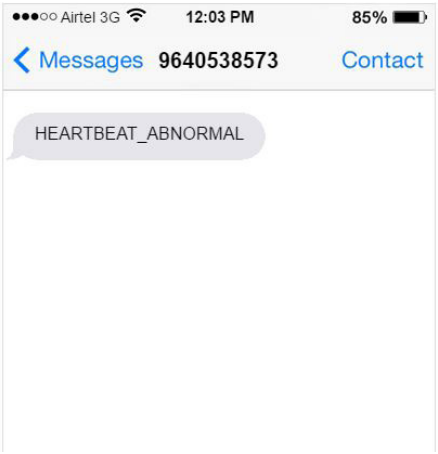

Figure 12: SMS Heart beat abnormal condition received by the doctor

Figure 13 depicts the SMS received to the doctor from the patient whenever the blood pressure is abnormal. As the patients blood pressure will be varying that is there may be low, medium, high blood pressure. By the Blood pressure kit is not in range then the doctor will be notified about the condition of Blood pressure through message and in advance medication will be provided.

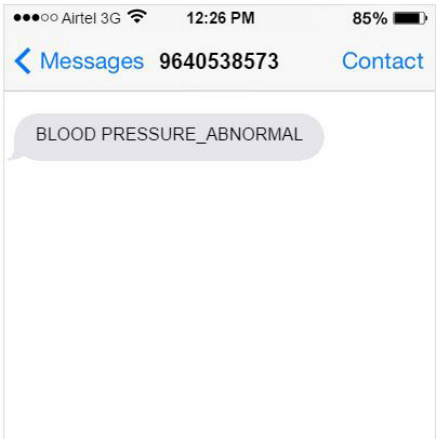

Figure 13: SMS Blood pressure abnormal received by the doctor

6. CONCLUSION

The developed Patient health monitoring system main objective is to provide the doctor with the patient's health parameters and to provide certain medication. This system assists the doctors and display the parameters in real time and in case of emergency an SMS facility is also provided. This system can be further modified and can be utilized to monitor the ECG signal. The developed system is a low cost, easy to use, accurate and provide the data in real time. The developed system is not confined to a single patient, with slight modification this system can be utilized to monitor more number of patients.

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