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Design of E-Health Monitoring of Patient using Internet of Things

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***Abstract*— In the recent development of Internet of Things (IoT) technology, it has made all objects interconnected. We can say that IoT has been recognized as the next technical revolution. To quote few of the applications of Internet of Things, smart parking, smart home, smart city, smart environment in the industrial places and in the irrigation and health monitoring process. One among these applications is the healthcare sector in which the patient health parameters are monitored. Internet of Things can make the medical equipments more efficient by allowing the real time monitoring of patient health, where the specific sensors used, acquire data of the patient. Since this technology sense and transmit the patient health data digitally, so it reduces the manual intervention and thus human errors. In Internet of Things patient's parameters get transmitted through medical devices via a gateway, where it is stored and analyzed. The significant challenges in the implementation of Internet of Things for healthcare applications are monitoring all patients from various places. Thus Internet of Things in the medical field brings out the solution for an effective patient monitoring at lower cost and also reduces the trade-off between patient outcome and disease management. In this paper, emphasized on the design of the system for monitoring patient's heart pulse rate, heart sound count and blood pressure using Raspberry Pi.**

***Keywords*— Raspberry Pi board, Heartbeat sensor, GPIO, Heart sound sensor, BP sensor, Camera, Internet of Things.**

I. INTRODUCTION

We are hearing the new technology now from all over the place. It is the “Internet of Things”. This technology is changing the lives of everybody in this new era in different sectors and domains like healthcare sector, agriculture, automobile industries, to name a few. This technology is evolutionary. The reason why public and the industries are using this technology is, it is available at the low cost at home. IoT can be used in monitoring patient’s health, for making smart home and smart city. The unexpected abnormality in the patient can be monitored using IoT. In this project specialized hardware sensors are used to monitor patient’s heart pulse rate, blood pressure and heart sound count.

One of the key learning platforms for IoT is Raspberry Pi. The Raspberry Pi is a popular platform because it offers complete Linux server in a small platform at a lower cost. The Raspberry Pi also allows interfacing the services and actuators through its general purpose input-output pins.

The IoT using Raspberry Pi has became a new innovation technology in the healthcare sector. Raspberry Pi acts as a small clinic after connecting the heart pulse, heart sound and blood pressure sensors. Raspberry Pi thus works as a small clinic in many places. Raspberry Pi can collect data from the sensors and then it can transfer the data to an user interface screen using QT Product IDE (Integrated Development Environment) tool framework. It also transfers the health data wirelessly to a Internet web browser for the user (health practitioner), who connects his/her internet to the Raspberry Pi using Raspberry Pi board’s inbuilt Wi-Fi. When Raspberry Pi board is connected to the internet network, the Raspberry Pi board’s physical MAC address gets registered in the internet. So when the user-health practitioner requests for the E-Health monitoring of the patient using local I.P Address of Raspberry Pi in his/her internet web browser, then the patient’s health sensors data output processed by Raspberry Pi is displayed in the internet web browser, in the form of a database report.

II. LITERATURE REVIEW

[1] Monitored the patient’s blood pressure utilizing Keep-In-Touch and a closed loop health related service. Keep-In-Touch device consists of the smart objects and two technologies: Neared field communication (NFC) and radio frequency identification (RFID). Keep In Touch uses a mobile phone that is based on the Java based application is communicated to the Keep-In-Touch device using nearer field communication (NFC). Based on the magnetic-inductive coupling, NFC technology works and uses a 13.56 MHz frequency band (free). So when the smart objects are brought closely, NFC enables short range communication between them. RFID technology is used to tag the objects and identify them, hence called smart objects. When the respective objects are touched, the application specific data is collected by the mobile phone. This mobile phone acts as a communication terminal by collecting data from the smart object and sends the data to the service centre. Through the service centre, both the health care practitioner and the patient are able to access the data and get the mutual feedback, regarding the patient’s blood pressure. This is called as closed loop health service.

[2] Monitored the ECG wave of the patient utilizing IOIO-OTG Microcontroller and can be monitored anywhere in the world. Here ECG parameter is monitored using an android

based application. Android mobile phone is connected to the IOIO-OTG microcontroller board wirelessly using Bluetooth technology. The patient's ECG wave data is collected by the microcontroller board. After collecting patient's data, the microcontroller sends the data to the android mobile phone. The phone stores the data temporarily in its SD card. When all the information data is collected by the mobile phone, it sends the data to a centralized cloud based server.

[3] Concentrated to collect the body temperature data checking utilizing raspberry hardware board and the cloud computing based framework. Here the raspberry pi is screens body temperature and after that this parameter is transferred using wireless sensor network to a cloud based server. This server provides on demand service to the user by enabling the user to access the computing resources on the demand. The computing resources include the application, network and the system.

[5] Monitored the glucose level for patient using non-invasive diabetic sensors and sent to the diabetics centre via IpV6 protocol. It uses TelosB sensor device having low power processor MSP430 is used to sense the patient glucose level using opto – physiological sensor as non-invasive sensor attached to the patient body and that collects the glucose level data and transferred to the centralized access points using low power personal area network (6LowPAN) communication standard. Then the data from this access point is sent using Internet Protocol version 6 (IPv6) to the diabetes management system having specialized IP addresses. It uses UDP protocol to transfer the data between the patient side node and the diabetes management department, in the transport layer.

[6] Examined monitoring patient's ECG, heart rate pulse and the temperature. PIC16F887A microcontroller collects the patient data from these sensors. Subsequent to gathering information from sensors, the information is transferred to the site by manual operation. The PPM sensor device is connected to the patient to record the heart pulse rate and LM35 sensor to measure body temperature. The PPM sensor is data is communicated to the microcontroller wirelessly. These data is transferred to an android mobile phone using GSM technology. This mobile phone is having an android based application developed and is used to monitor purpose and created a web page for the monitoring of health status.

[9] Worked to monitor the electro cardio gram for the patient. It uses a microcontroller called as ATmega16L. This microcontroller observes the patient Electro cardio gram waves. It uses a zigbee based module and transfers the electro cardio gram waves. This zigbee based module will send the information to closest connected zigbee based network.

[10] Has implemented monitoring, controlling for the home appliance utilizing Android based cell phone. For this, an Arduino UNO board gets associated with home appliance-light, fan. It uses an Android based application which is created to make application as Smart Home. An arduino board and the android application is communicated and are associated to a website. Utilizing this Android based application, patient monitoring, control for the home appliance anyplace in the world is made possible.

[16] Has implemented the heart pulse monitoring of the patient using wireless zigbee technology. Here the PIC16F887 microcontroller is used to interface the patient's heart beat rate using heart beat sensor. It is programmed to read the patient's sensor data, process it and send it wirelessly to the doctor's computer using zigbee module. The zigbee module at the patient side with PIC microcontroller acts as zigbee transmitter module and the zigbee module interfaced with the doctor's computer acts as zigbee receiver. Zigbee modules used have the same design. So the firmware used for the two is differing, where doctor side zigbee module acts as zigbee coordinator or the master and the patient side zigbee module acts as zigbee slave. The patient health data is displayed on the doctor's computer on a GUI based screen.

[17] Has implemented monitoring of patient' body movement. Raspberry Pi Board was used for it. The sensor used to measure patient's body movement is MMA7260QT accelerometer sensor. This sensor is fixed to the patient bed and it uses 3 axis X, Y, Z to measure the body movement. Based on the body movement, sensor calculates the X, Y, Z values. It has two capacitive micro-machined capacitive sensing cells (called g-cells) and one signal conditioning circuit (ASIC) on one board. The ASIC provides signal switched capacitor method to switch the capacitive cells based on the body movement and get provides signal switched capacitor method to switch the capacitive cells based on the body movement. The difference between the capacitors is the acceleration data. The acceleration data is also used to get the high level output voltage in proportion to the acceleration. Accelerometer is interfaced with the Raspberry Pi Board to get the output. Raspberry Pi board is connected to a laptop using data cable. The laptop is installed with Putty terminal emulator software, to configure it as a Secure Shell (SSH) client and the Raspberry Pi will become the SSH server. By changing the IP address of Raspberry Pi in the putty session, one can see the patient's body movement values in the Putty session.

III. METHODOLOGY

This paper uses Raspberry Pi Board as an IOT device that interfaces four sensors and read the patient health parameters. Figure 1 shows the functional block diagram of the application. The three sensors: heart beat pulse sensor kit, blood pressure sensor kit and heart sound sensor kit sense the patient health parameters and the output of each sensor kit is given as input to the raspberry pi board through the GPIO Header pins on the Raspberry Pi Board. Fourth Sensor is the raspberry pi camera that is used to take the image of the patient and send it as input to the raspberry pi board through the 15 pin camera serial interface connector. Then image of the patient and his/her health parameters are sent to user interface page, and an internet web page so that the health practitioner can connect to raspberry pi through internet and raspberry pi inbuilt Wi-Fi.

The Raspberry pi is programmed to configure the GPIO port so that each health sensor kit output data is read through the configured port and the data is processed to monitor the corresponding health data on graphical user interface page on the Raspberry pi monitor and also monitored on the web page of the internet browser of the user (health practitioner) by connecting to raspberry pi using its Wi-Fi and I.P address. Raspberry Pi is powered using a 5V supply at its MicroUSB port and using a keyboard and mouse, the linux commands are typed on the LX terminal monitor for executing the programs stored in a project folder under root directory. The programs sense the patient health data output from the specific sensor and the data is processed and monitored on a user interface screen in the raspberry pi's Lx terminal monitor. The health parameters are also monitored on a web page, so that the user can monitor the patient health parameters on his/her internet browser page by accessing the I.P address of raspberry pi through internet and raspberry pi's inbuilt Wi-Fi , using Wi-Fi network SSID and password.

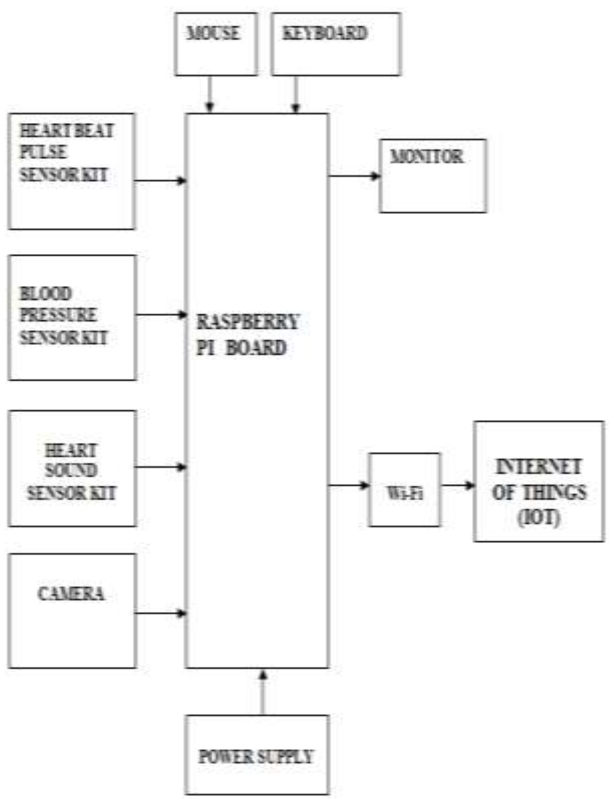

Fig 1: Block diagram of Patient Monitoring system using Raspberry Pi

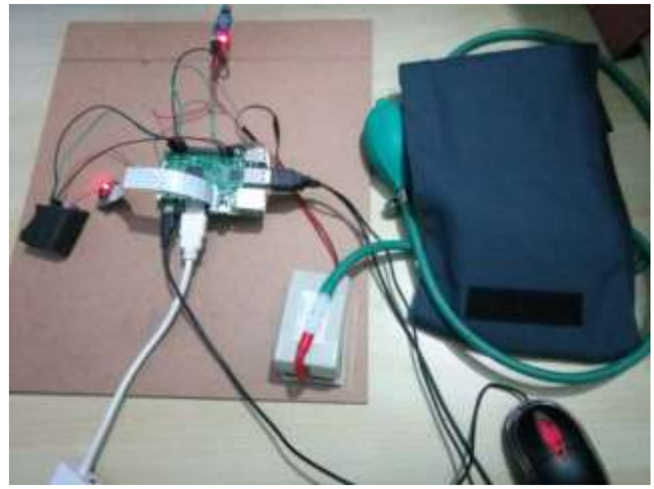

Fig 2: Hardware connection setup for Patient Monitoring system using Raspberry Pi

Figure 2 shows the hardware connection setup of raspberry pi board with the health sensors, raspberry pi camera. The heart pulse sensor kit has an infrared LED source and a photodetector, side by side. The patient's finger tip is placed in between these components and act as reflector of the incident light from the LED. The amount of reflected light from the fingertip is detected by the photo detector. The output of the photo detector is actually an electrical signal containing DC component related to blood volume and an AC component caused by the pulsatile changes in the fingertip arterial blood volume that is synchronous with the heart beat. The kit has two signal conditioning stages, first stage to isolate the AC component from the photo detector output using highpass-lowpass filters combinations and amplify the weak pulsatile AC component by 101 times. The second stage has a similar highpass-lowpass filters combination to further amplify the output of first stage to make the signal ac component gain increase by another 101 times, so that the signal is nearly equal to TTL pulse and synchronous with the heart pulse. The raspberry pi board reads this pulse from the kit through its GPIO configured port pin and waits for seconds to get the heart beat rate in beats per minute and sends this parameter to user interface page on the monitor connected to the raspberry pi board. The parameter is also send to a web page created by the PHP script, so that a user when connected to raspberry pi through its Wi-Fi and internet, can see the patient heart pulse parameter data online using IP address of raspberry pi.

The heart sound sensor module kit has a microphone sound sensor that can detect the simulated heart sound and is given as input to a voltage comparator, which compares the heart sound sensor output with a reference voltage of 3.3V and its output is either high or low depending on the heart sound is above or below the threshold voltage. This Analog pulse output is converted to digital pulse using a 8 channel analog to digital converter present in the kit and its digital output is read by the raspberry pi using its configured GPIO header pin. The raspberry pi waits for sixty seconds and reads this heart sound, and sends this output to a user interface page on the monitor connected to the raspberry pi. The interface page is designed using QT creator tool. So every 60 seconds, the heart sound rate is monitored on the monitor. Also this parameter value is send to a web page of the user internet browser, by connecting raspberry pi to the user's internet using raspberry pi's inbuilt Wi-Fi and IP address. The web page is designed using PHP and using mysql database-server, the webpage data is retrieved and put on the web page.

The blood pressure sensor kit is having patient arm pressure cuff, air bladder pump, a transducer to convert pressure to electrical signal and analog to digital converter to convert analog voltage signal to digital serial UART eight bit data value, which is in ASCII form. Actually the blood pressure is the force of the blood against walls of the arteries. It is measured by two values high and low value called as systolic pressure and diastolic pressure. Usually, systolic pressure is the higher pressure, usually a value of 120 mmHg for a healthy person and diastolic pressure is the lower pressure, usually a value of 80 for a healthy person. Once the cuff is placed over the patients' upper arm, tighten the valve on the end of the air pump and start squeezing the pump to inflate the cuff so as to reach a pressure about 20 mmHg above the systolic pressure for any individual. When the cuff is fully inflated to this pressure, then it cuts off blood flow to the arm, stopping the pressure so that the pressure sensor can accurately record when the pressure returns.

A valve on the end of the pump bulb is loosened to release the air from the cuff. The tester slowly releases the air and the cuff loosens, allowing blood flow. The sensor registers the blood flow as circulation returns and the moment when the blood begins to flow through the artery, gauge should jump or pulse in time with the blood pulsing in the artery. This is systolic pressure and is measured by the differential output of the pressure sensor (in analog form), and then is converted to a digital UART 8 bit data value and is read by the Raspberry Pi from its UART receiver pin. This value is converted from 8bit UART ASCII value to integer value and sent to the user interface page on the monitor connected to raspberry pi board. The user interface program is developed using QT Creator IDE. Thus the blood pressure value is monitored on the user interface page of the monitor. The blood pressure systolic value is also send to the web page of the internet browser, when the user connects to raspberry pi using its Wi-Fi and internet IP address. The web page is designed using PHP and using mysql database-server , the webpage data is retrieved and put on the web page, when the BP value crosses systolic value. Also, an email alert is sent to the healthcare provider(doctor, specialist, nurse) email address using python, script configured using SMTP server details (email address of sender and receiver, and the alert message) to alert that the patient needs medication for hypertension.

To capture the image of the patient, a raspberry pi camera of eight Mega pixels is connected to the 15 pin MIPI (Mobile Industry Processor Interface) Camera Serial Interface of Raspberry Pi-3 Board. So when the Raspberry Pi is powered up, the image of the patient is used to upload to the GUI page of the LX terminal monitor as well as on the web page for the client who requests for E-Health data of patient through the Internet using the raspberry pi's IP address. Thus this camera interface feature of raspberry Pi is used to identify the patient on the web.

IV. CONCLUSION AND FUTURE WORKS

Fig 3: Sensors output in GUI page of Raspberry Pi Monitor

Also figure 4 shows that raspberry Pi hosts locally the web page for the patient's health monitoring system with the patient's E-Health monitoring parameters, which is seen when the healthcare provider connects to the Raspberry Pi' local IP Address followed by E-Health web page through the internet connection and connecting to Raspberry Pi by Wi-Fi. So whenever the doctor or any other user who requests the patient health information can get the information when he/she access the Raspberry Pi using the IP address for the Raspberry Pi in the internet using Raspberry Pi Wi-Fi Facility locally in a Hospital Campus. Thus each patient with his health sensors interfaced to one Raspberry Pi can be monitored in the internet web page of internet browser of the hospital campus, when the healthcare provider requests the patient's health parameters through the patient's raspberry pi's IP Address followed by E-Health page in the internet web browser. In this scenario the IP address is 192.168.43.185/EHealth. Even the doctor gets an alert message when the patient is having hypertension, so that the patient gets medication immediately. This E-Health monitoring System can be used in the Hospital campus wireless local area network only as the Raspberry Pi computer is hosted as a local server to be used in one hospital local area network only. Thus One Raspberry Pi can be used as a server for one patient. Thus multiple raspberry Pi can be used, one for each patient to monitor his/her health parameters using specific sensors and monitor it on a graphical user interface monitor screen; Also can be monitored on the internet web page by connecting each Raspberry Pi Board to the Internet source using raspberry pi's inbuilt Wi-Fi and the internet network's SSID and password, and requesting each patient's E-Health parameters through each patient's Raspberry pi's unique IP address in the Internet web browser.

Fig 4:Raspberry Pi web server output in client internet browser.

In Future, the network can be made globally by making use of routers that route the patient E-Health monitoring data outside the hospital network into global network, so that anybody over the internet globally, can monitor every patient's E-Health parameters and the patient will be attended immediately for his abnormal health conditions globally by the healthcare providers. Also, add the other sensors like body temperature sensor, glucose level sensor to the current system and monitor those sensors related parameters.

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