IOT BASED INTEGRATED SMART HEALTH CARE SYSTEM ON CLOUD COMPUTING

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ABSTRACT

Health is one of the global challenges for humanity. In the last decade the healthcare has drawn considerable amount of attention [1]. Technology plays the major role in healthcare not only for sensory devices but also in communication, recording and display device. It is very important to monitor various medical parameters and post operational days. Hence the latest trend in Healthcare communication method using IOT is adapted. Internet of things serves as a catalyst for the healthcare and plays prominent role in wide range of healthcare applications. The prime goal of the project is to develop a reliable patient monitoring system so that the healthcare professionals can monitor the patients who are hospitalized. Recently, the patient monitoring systems is one of the major advancements because of its improved technology. Currently, there is need for a modernized approach. In the traditional approach the healthcare professionals play the major role. They need to visit the patients ward for necessary diagnosis and advising. The basic problem associated with traditional approach is, the healthcare professionals must be present on site of the patient all the time, to know the status regularly during critical conditions. In order to solve this problem, there is a need to develop a reliable patient monitoring system so that the healthcare professionals can monitor their patient's remotely. The project presents a mobile device based wireless healthcare monitoring sys- tem that can provide real time online information about physiological conditions of a patient. In this project, Raspberry pi is used as an integral part for processing and sensors like Temperature, Pulse/Heart rate and PIR are used. These sensors are connected to Arduino board and the sensor values are read from the Arduino and transmitted to pi through serial communication. Now, the sensor values are stored in a file in pi and the same file is uploaded to the cloud through internet. Finally, this uploaded data is retrieved via user app.

Keywords—*Raspberry Pi board; Heartbeat sensor; Temperature sensor; Cloud; Internet of things.*

1. INTRODUCTION

Today Internet has become one of the important part of our daily life. It has changed how people live, work, play and learn. Internet serves for many purpose educations, finance, Business, Industries, Entertainment, Social Networking, Shopping, E-Commerce etc. The next new mega trend of Internet is Internet of Things (IOT).

Visualizing a world where several objects can sense, communicate and share information over a Private Internet Protocol (IP) or Public Networks. The interconnected objects collect the data at regular intervals, analyze and used to initiate required action, providing an intelligent network for analyzing, planning and decision- making. This is the world of the **Internet of Things (IOT).**The IOT is generally considered as connecting objects to the Internet and using that connection for control of those objects or remote monitoring. But this definition was referred only to part of IOT evolution considering the machine to machine market today. But actual definition of IOT is creating a brilliant, invisible network which can be sensed, controlled and programmed. The products developed based on IOT include embedded technology which allows them to exchange information, with each other or the Internet and it is assessed that about 8 to 50 billion devices will be connected by 2020. Since these devices come online, they provide better life style, create safer and more engaged communities and revolutionized healthcare. The entire concept of IOT stands on sensors, gateway and wireless network which enable users to communicate and access the application/information. Be that as it may, among all the regions no

place does the IOT offer more prominent guarantee than in the field of health awareness. As a saying goes "Health is wealth" it is exceptionally crucial to make utilization of the innovation for better wellbeing. Consequently it is obliged to add to an IOT framework which gives secure health awareness checking. So outlining a savvy medicinal services framework where client information is gotten by the sensor and sent to the cloud through Wi-Fi and permitting just approved clients to get to the information.

To improve human health and well-being is the ultimate goal of any economic, technological and social development. The concept of the IoT entails the use of electronic devices that capture or monitor data and are connected to a private or public cloud, enabling them to automatically trigger certain events [2].

2. MOTIVATION

Health is the fundamental capability humans require to perceive, feel, and act effectively, and as such, it represents a primary element in the development of the individual, but also of the environment humans belongs to [3]. That is why it is necessary to provide adequate ways and means to ensure the appropriate healthcare delivery based on parameters monitoring and direct providing of the medical assistance. The new technologies development and implementation, especially the Internet and Wireless Sensor Networks (WSNs) commonly known as the Internet of Things (IoT), enable global approach to the health care system infrastructure development. This leads to e-health system that, in real time manner, supplies a valuable set of information relevant to all of the stakeholders (patients, medical and paramedical stuff, and health insurance) regardless their current location. In many cases, the real time parameter values are not being efficiently measured in clinic as well as in hospital, it becomes difficult for hospitals to frequently check patient's health conditions, and also it is not possible for continuous monitoring of ICU patients. To deal with these types of situations, this system is beneficial. This project is designed to be used in hospitals for measuring and monitoring various parameters like temperature, heart beat rate, movement. The results can be recorded using Raspberry Pi which will be displayed on a monitor. And the result is stored in cloud and can be sent to user end application using Wi-Fi. Doctors can login to an app and view those results.

3. OBJECTIVE OF THE PROJECT

The project aims at developing a reliable patient monitoring system which enables doctor to continuously monitor the patient's health status remotely. In this project, the monitoring of patient is done by the doctor continuously without actually visiting the patient. Here, various sensors are used to sense the physiological parameters like temperature, heart beat rate, movement. These sensed signals are transmitted to the Raspberry pi to update the data continuously, via ADC which will convert the analog signals into digital signals. Through Wi-Fi the data is sent to cloud and it is stored, then the data is sent wirelessly to the user end application. So, the doctor can visualize the patient's data just by sitting in his cabin. When a critical condition occurs, he takes necessary measures to the patient.

4. PROBLEM DEFINITION

In today's social insurance framework for patients who stays in home during post operational days checking is done either via overseer/ medical caretaker. Ceaseless observing may not be accomplished by this system, on the grounds that anything can change in well being parameter inside of part of seconds and amid that time if guardian/attendant is not in the premises causes more noteworthy harm. So with this innovation created period where web administers the world gives a thought to add to another keen health awareness framework where time to time constant checking of the patient is accomplished.

5. PROPOSED SYSTEM

The entire system can be divided into mainly three sections, namely Sensor Node, Cloud Backend and User Node. The sensor values is received and analyzed by raspberry-pi through Atmega-328 which will convert analog values to digital and sent to cloud storage and user, via internet. The detailed block diagram of the system is shown in Figure 1. which includes mainly the Sensor Node, Cloud Backend and the User Node.

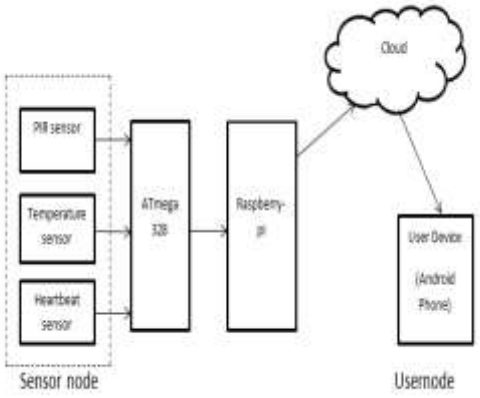

Fig-1: Block Diagram of Remote Patient monitoring system.

Sensor Node

Sensor node consists of various sensors that are used to sense the physiological parameters like temperature, heartbeat rate, and movement. These sensed signals are sent to ATmega-328, which will convert the analog signals into digital signals, these values are transmitted to the Raspberry-pi to update the data continuously to cloud. temperature sensor is used to sense the temperature. PIR sensor is a device that detects motion of a patient. Heart beat sensor is designed to give digital output of heart beat when a finger is placed on it.

Cloud

Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over the network (mainly the Internet). Cloud has abundant processing power, large amount of storage which can be scaled according to application needs. Modern technology is being shifted to Cloud based platform as it is suited for long-term data storage. For the implementation of proposed system, cloud storage such as Dropbox is used. Dropbox gives enough space to back up all the files and with a simple admin interface for adding new users.

User Node

This is a user support layer. It is a platform from where user can access sensor data and can analyze the patient's condition. User node is an android app in an android phone. User (doctor) is able to receive the sensor data, and gets the push notification if the sensor value exceeds the threshold value and also different patient details can be viewed via report in an app.

6. HARDWARE DESCRIPTION

This deals with the physical entities used in the system. It incorporates all the devices used. The heart of the system is raspberry-pi, which controls and monitors the overall behavior of the system. In this chapter, various sensors used for monitoring different parameters are discussed, along with raspberry-pi, arduino uno and any other hardware component used in the system.

a) Raspberry Pi

The Raspberry Pi 3 Model B is the third generation Raspberry Pi. This powerful credit-card sized single board computer can be used for many applications and supersedes the original Raspberry Pi Model B+ and Raspberry Pi 2 Model B. Whilst maintaining the popular board format the Raspberry Pi 3 Model B brings you a more powerful processor, 10x faster than the first generation Raspberry Pi. Additionally it adds wireless LAN and Bluetooth connectivity making it the ideal solution for powerful connected designs. The Raspberry Pi 3 model B features a Broadcom BCM2387 system which includes ARM Cortex-A53 Quad Core Processor powered Single Board Computer running at 1.2GHz. It has 1GB RAM and 64bit CPU. It consists of 4 USB ports, 40pin extended GPIO to enhance the real world projects, CSI camera port for connecting the Raspberry Pi camera, DSI display port for connecting the Raspberry Pi touch screen display, Micro SD port for loading the operating system and storing data. Boots from Micro SD card, running a version of the Linux operating system

or windows 10 IoT. It has 10/100 BaseT Ethernet socket to quickly connect the Raspberry Pi to the Internet. And Micro USB power source socket with 5v voltage and 2A current. The detailed diagram of the raspberry-pi board is shown in the Figure 2.

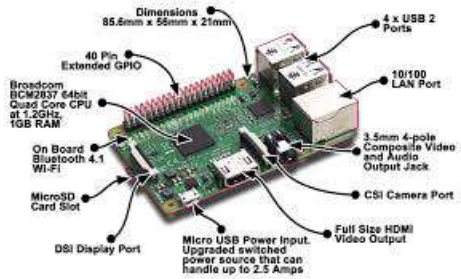

Fig-2: Raspberry-pi 3 Model B.

b) Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The detailed description of the arduino board is shown in the Figure 3.

"Uno" means one in Italian and is named to mark the upcoming release of Arduino 1.0.
The Uno and version 1.0 will be the reference versions of Arduino, moving forward. The Uno is the latest in a series of USB Arduino boards, and the reference model for the Arduino platform.

Some of the key features of the Arduino Uno include:

- An open source design. The advantage of it being open source is that it has a large community of people using and troubleshooting it.
- An easy USB interface. The chip on the board plugs straight into the USB port and registers on to computer as a virtual serial port. This allows to interface with it as through it were a serial device. The benefit of this setup is that serial communication is an extremely easy (and time tested) protocol, and USB makes connecting it to modern computers really convenient.
- An on-board LED attached to digital pin 13 for fast an easy debugging of code.

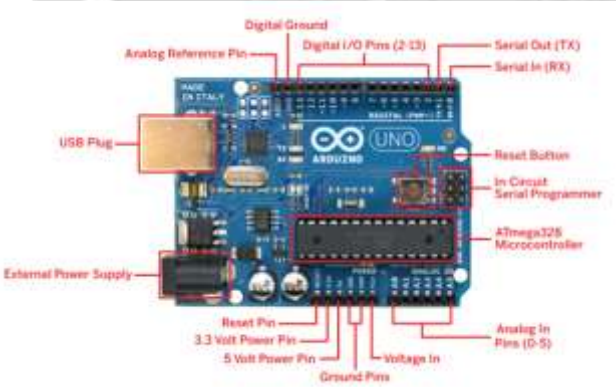

Fig-3: Arduino uno board.

- Very convenient power management and built-in voltage regulation. Connecting an external power source of up to 12v and it will regulate it to both 5v and 3.3v. It also can be powered directly off of a USB port without any external power.
- An easy-to-find, and dirt cheap, microcontroller "brain". The ATmega328 chip. It has number of nice hardware features like timers, PWM pins, external and internal interrupts, and multiple sleep modes.
- A 16 MHz clock. This makes it not the speediest microcontroller around, but fast enough for most applications.

- 32 KB of flash memory for storing the code.

- 13 digital pins and 6 analog pins. These pins allow connecting external hardware to the Arduino. These pins are key for extending the computing capability of the Arduino into the real world. Simply plug the devices and sensors into the sockets that correspond to each of these pins.
- An ICSP connector for bypassing the USB port and interfacing the Arduino directly as a serial device. This port is necessary to re-boot load the chip if it corrupts.
- A button to reset the program on the chip.

c) ATmega 328

The ATmega328 is a single-chip microcontroller created by Atmel in the megaAVR family. The Atmel 8-bit AVR RISC-based microcontroller combines 32 kB ISP ash memory with read-while-write capabilities, 1 kB EEPROM, 2 kB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, maximum operating frequency of 20MHz, serial programmable USART, a byte-oriented 2-wire serial interface, SPI serial port, 6-channel 10-bit A/D converter, programmable watchdog timer with internal oscillator, and five software selectable power saving modes. The device operates between 1.8-5.5 volts. The device achieves throughput approaching 1 MIPS per MHz. The ATmega 328 chip is as shown in the Figure 4.

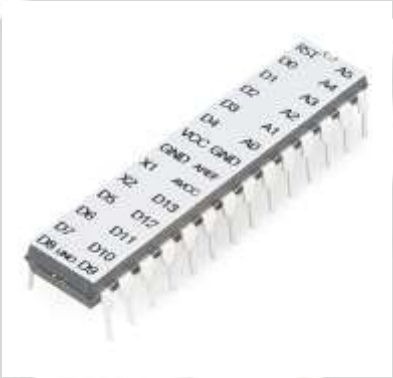

Fig-4: ATmega 328 chip.

d) Temperature Sensor

Temperature sensor is a device which senses variations in temperature across it. LM35 is a basic temperature sensor that can be used for experimental purpose. It give the readings in centigrade (degree Celsius). The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. It Operates from 4 to 30 volts and has less than 60 Micro ampere current drain. The temperature sensor can be viewed as shown in the Figure 5. The circuit connections are made as follows:

- Pin 1 of the LM35 goes into +5V of the Arduino.
- Pin 2 of the LM35 goes into analog pin A0 of the Arduino.
- Pin 3 of the LM35 goes into ground (GND) of the Arduino.

Fig-5: Temperature Sensor.

e) Motion Sensor:

PIR sensors allows to sense motion, almost always used to detect whether a human has moved in or out of the sensors range. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason

they are commonly found in appliances and gadgets used in homes or businesses. They are often referred to as PIR, "Passive Infrared", "Pyroelectric", or "IR motion" sensors. The PIR (Passive Infra-Red) Sensor is a pyroelectric device that detects motion by measuring changes in the infrared levels emitted by surrounding objects. This motion can be detected by checking for a high signal on a single I/O pin A PIR detector combined with a Fresnel lens are mounted on a compact size PCB together with an analog IC,SB0081, and limited components to form the module. High level output of variable width is provided. The PIR sensor has a detection range, ranging from 2-3meters. Supply voltage of 3-5v.Current drain is less than 50uA Temperature ranges from -15C to +70C. The PIR sensor back view is as shown in Figure 6a. And front view is as shown in Figure 6b.

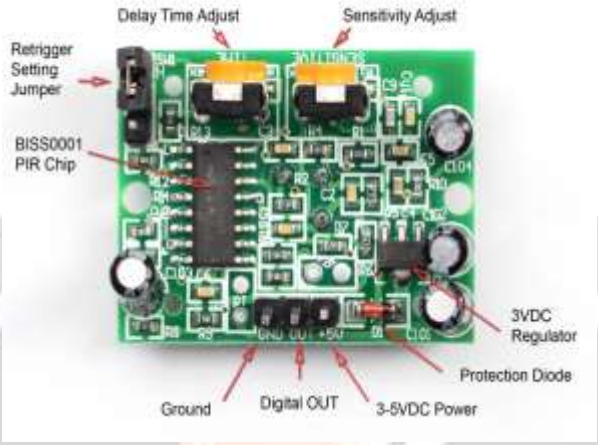

Fig-6a: PIR sensor back view.

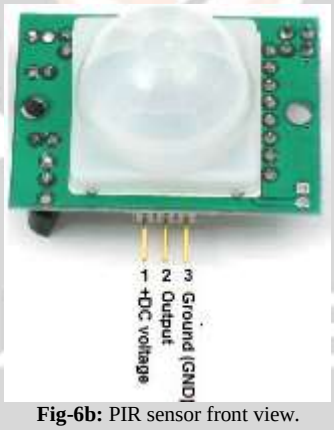

Fig-6b: PIR sensor front view.

f) Pulse/Heart Rate Sensor

Heart rate is the speed of the heartbeat measured by the number of contractions of the heart per minute (bpm). The heart rate can vary according to the body's physical needs, including the need to absorb oxygen and excrete carbon dioxide. It is usually equal or close to the pulse measured at any peripheral point. Activities that can provoke change include physical exercise, anxiety, sleep, stress, illness, and ingestion of drugs. Many texts cite the normal resting adult human heart rate range from 60 to 100 bpm. Tachycardia is a fast heart rate, defined as above 100 bpm at rest. Bradycardia is a slow heart rate, defined as below 60 bpm at rest. Several studies, as well as expert consensus indicates that the normal resting adult heart rate is probably closer to a range between 50 to 90 bpm. During sleep a slow heartbeat with rates around 40 to 50 bpm is common and is considered normal. When the heart is not beating in a regular pattern, this is referred to as an arrhythmia. Abnormalities of heart rate sometimes indicate disease.

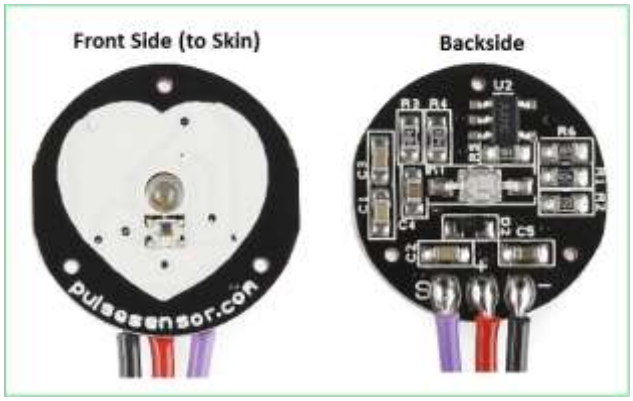

Fig-7: Front side and backside of the heartbeat sensor.

Pulse Sensor is a well-designed plug-and-play heart-rate sensor for Arduino. It can be used by students, artists, athletes, makers, and game and mobile developers who want to easily incorporate live heart rate data into their projects. The sensor clips onto a fingertip or earlobe and plugs right into Arduino. The front and back view of the heartbeat sensor is as shown in Figure 7.

The Pulse Rate Sensor should be connected to Uno as follows:

- Signal(S) to A0
- Vcc(+) to 5V
- Gnd(-) to Gnd

7. SYSTEM IMPLEMENTATION

In this, the methodology used for realizing the system is discussed. The sensor node, cloud and end user device will come into picture while realizing the system in a sequential manner. The sensor node captures the data and sends it to cloud, from cloud data is retrieved by user node. All the sensed signals from arduino is sent to raspberry-pi through serial communication. In raspberry-pi python program is executed, output is seen in python shell. In this system

Dropbox cloud storage is used, in order to access this dropbox, an account is created which generates a key. Insert this dropbox key to Pi code for authentication to upload and download the data. URL that is generated as output in python shell is copied to the dropbox developers, in dropbox developers access token is generated, which is copied to the output window. The sensor output is seen on the pi desktop and the same data is stored in a file. When internet connection is established the same file will be uploaded to cloud storage. From cloud the senor data is retrieved by user App. And it also gets push notification, if sensor value is greater than threshold value.

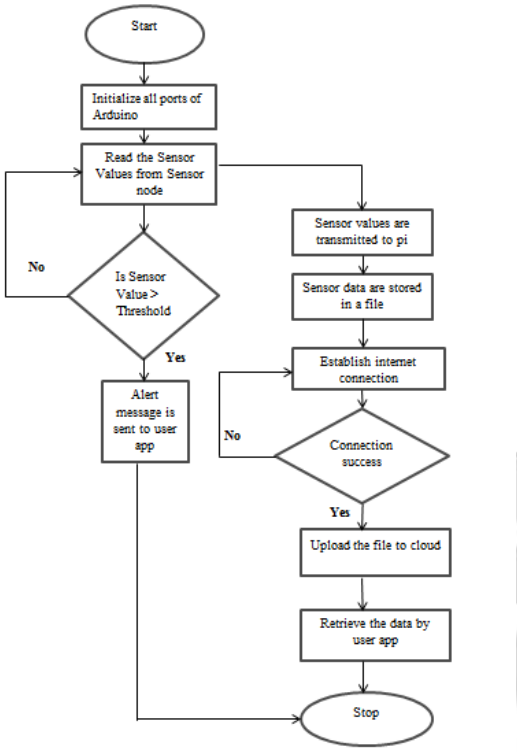

Fig-8: Flowchart for Remote Patient Monitoring System -an IoT based approach.

Figure 8, illustrates the sequence of activities in the Remote Patient Monitoring System. Initializing all the ports of arduino Uno and recording the sensor data from sensor node then comparing it with pre-initialized values. If the sensor value is greater than threshold, alert message is sent to user App. Otherwise sensor data is pushed to Raspberry pi and stored in a file. When the internet connection is established, the file will be uploaded to cloud storage and is sent to user node.

8. SOFTWARE DESCRIPTION

This describes the softwares that are used in the project. It deals with the Raspbian Operating System (OS) that is used in the raspberry pi, python language which is used for programming of raspberry pi and Arduino Software (IDE) is used for programming of sensors. The cloud storage service i.e. Dropbox is used for storing the sensor data from pi and finally Android studio is used for creating an user app which retrieves data from the cloud.

a) NOOBS (New Out Of the Box Software)

NOOBS is an easy operating system installer that contains Raspbian. It also provides a selection of alternative operating system which is then downloaded from the internet and installed. NOOBS is directly downloaded from the website onto a formatted SD card.
@ https://www.raspberrypi.org/downloads/noobs/

b) Raspbian

Raspbian is a free operating system based on Debian optimized for the Raspberry Pi hardware. An operating system is the set of basic programs and utilities that make Raspberry Pi run. However, Raspbian provides more than a pure OS: it comes with over 35,000 packages; pre-compiled software bundled in a nice format for easy installation on Raspberry Pi.

Raspbian is highly optimized for the Raspberry Pi line's low-performance ARM CPUs. It uses PIXEL, Pi Improved Xwindows Environment, Lightweight as its main desktop environment as of the latest update. It is composed of a modified LXDE desktop environment and the Open box stacking window manager with a new theme and few other changes.

c) Python

Python is an interpreted, object oriented, high-level programming Language with dynamic semantics. Its high-level built in data structures, combined with dynamic typing and dynamic binding makes it very

attractive for Rapid Application Development, as well as for use as a scripting or glue language to connect existing components together. Python's simple, easy to learn syntax emphasizes readability and therefore reduces the cost of program maintenance. Python supports modules and packages, which encourage modularity and code reuse. The python interpreter and the extensive standard library are available in source or binary form without charge for all major platforms, and can be freely distributed. Python 2.7 version, which is pre-installed in Raspbian OS, is used in the project for programming of raspberry pi.

d) Cloud

Cloud computing is a type of Internet-based computing that provides shared computer processing resources and data to computers and other devices on demand. It is a model for enabling ubiquitous, on-demand access to a shared pool of configurable computing resources (e.g., computer networks, servers, storage, applications and services). Cloud computing and storage solutions provide users and enterprises with various capabilities to store and process their data in third-party data centers. The cloud storage service used in this project is Dropbox.

e) Dropbox

Dropbox is cloud storage service that enables users to store files on remote cloud servers and the ability to share files within a synchronized format. Dropbox provides an online storage solution powered by cloud computing service model of Infrastructure as a service (IaaS). Dropbox users are provided by an online storage space hosted on Dropbox accessible anywhere via the Internet. The storage space provides storage for virtually any kind of file type from documents, images, videos etc. It works by installing an application on client system, which immediately uploads the data to their own cloud storage servers. The uploaded data can be accessed from the installed application or through an online control panel. In this project, Dropbox is used for storing the sensor data which is received from raspberry pi.

f) Arduino Software: Arduino 1.8.1

The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board. It runs on Windows, Mac OS X and Linux. The environment is written in Java and based on Processing and other open-source software. This software can be used with any Arduino board.

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino Uno hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension .ino. The editor has features for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino Software (IDE), including complete error messages and other information. The bottom right-hand corner of the window displays the configured board and serial port. The toolbar buttons allow you to verify and upload programs, create, open, and save sketches, and open the serial monitor. In this project, Arduino software is used for writing program for sensors which are connected to the Arduino board and the same program is compiled and uploaded to the board. The output is then observed on the serial monitor in Arduino.

g) Android Studio

Android Studio is integrated development environment (IDE) for the Android platform. Android is an open-source mobile phone operating system based on Linux and developed by Google and now a day it becomes the most widely used Operating System on mobile phones. Java language codes are used to develop android mobile application which allows developers to write codes in the Java language. Using Google enabled Java libraries these codes can control mobile devices. Android mobile Operating System also provides a flexible environment for development of Android Mobile Application as the developers can not only make use of Java IDEs but it is also possible to use Android Java Libraries. Android Mobile Application Development is basically used to create user friendly and innovative Applications. Android is an open source architecture that includes the Operating system, application framework, Linux kernel, middleware and application along with a set of API libraries for writing mobile applications that can give look, feel, and function of mobile handsets. In the project, Android Studio is used for creating an app which retrieves the data directly from cloud.

9. CONCLUSION

The project Remote Patient Monitoring System is a telemedicine application which allows the doctor to view the patient's vital signs and parameters remotely and dynamically in real time. A smartphone based health

monitoring system has been presented in this project. By using the system, the healthcare professionals can monitor, diagnose, and advice their patients all the time. The physiological data are stored and published online. Hence, the healthcare professional can monitor their patients from a remote location at any time. The system is power efficient, cost effective, flexible and robust solution supporting a unique mobile based computational platform . It is easy to use, fast, accurate, high efficiency, and safe (without any danger of electric shocks).
In this project, the realized system can be a prototype for health care system to monitor patient's health status continuously. The system is comprised of low-power profile sensors to measure various physiological parameters of the patient. Raspberry pi is used for this application because of its multi-tasking capability and low power consumption. Dropbox is used for cloud storage. Also this system can be installed easily in all the hospitals and huge data obtained can be stored in the database, which are very much valuable. Even the results can be made to be accessed from mobile through an application. In contrast to other conventional medical equipment, this system has the ability to save data for future reference. Finally, the reliability and validity of this system have been ensured via field tests. The field tests show that our system can produce medical data that are similar to those produced by the existing medical equipment.

10. FUTURE WORK

The Future work of the project is very essential in order to make the design system more advanced. In the designed system the enhancement would be connecting more sensors to internet which measures various other health parameters and would be beneficial for patient monitoring i.e. connecting all the objects to internet for quick and easy access. Establishing a Wi-Fi mesh type network to increase in the communication range.
We can connect to all the other branches of the concerned hospital and thus the critical patient's data can be sent and observed for better treatment. Healthcare costs can be reduced because issues can be addressed before they become acute, which could lead to fewer hospital visits. It will be easier for relatives and other remote caregivers to keep track of their relative's health from a distance. In the home we will guide one educated person instead of Doctor about treatment with respect to basic medicine when the sensor value reaches greater than threshold value.Instead of medical application we can use our system in industrial and agricultural application by using sensors like humidity sensors, fertility check sensors, and many more.

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