

IoT BASED HEALTH MONITORING SYSTEM

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Abstract— *Internet of Things (IoT) is the emerging paradigm, which contains huge amount of smart object and smart devices connected to the internet for communicating with each other. The patient monitoring system has been developed using IoT technology to monitor health conditions for chronic diseases such as heart attack among others and serve the data to the cloud where it will be accessed remotely through different analytics applications on IoT android phones and other wearables. The data from different sensors will be sent to the cloud through thinger.io cloud platform. The data from the cloud can then be visualized and analyzed by the thinger.io dashboards, the IoT compatible android phones and the specially designed mobile and desktop applications. In this way, the user can easily view the data and interpret it so that required actions be taken. Therefore, the main purpose of this system is to provide real time health data that will keep the doctor of a patient and other guardians updated, so that proper actions are taken in time when special attention is needed from a remote distance. In this way, sudden deaths due to unmonitored health conditions of home based patients, the old, children, the disabled will be reduced as the same will be closely monitored. In addition to this, the system will help to stabilize the economic status of the affected family, since they will be able to do some other work while following up the health status of their sick.*

Index Terms— *Healthcare, Internet of Things, Wireless sensor, Body Area Network, Pulse rate*

I. INTRODUCTION

This is the system that is being developed using the internet of things technology to outsource health data to the cloud from where it can be accessed by different people. These people could be those trusted and doctors that will have a clear picture of one's health status and decide on the best and timely actions to be undertaken. It is through the same technology that continuous assessment of person's health can be taken unlike when one is sick only. People suffering from chronic diseases such as heart attack and high blood pressure need "a now and then assessment" of their health status and this will be made possible by this system which will be getting this data from the body and send them to the cloud and this data is then interpreted by special data analyzing and visualizing mobile and desktop applications that have been developed to interpret the data for easy understanding by the user and the other people concerned (guardians and doctors). The whole system will be put together by the use of a microcontroller (Arduino UNO). This microcontroller is the one that through a code, will be outsourcing the sensor data to thinger.io, a cloud platform that allows this data to be accessed through different gadgets and means. The security and integrity issues on the access of these data has been addressed by the cloud platform itself. The private API address which is used for accessing specific data for a specific cloud platform on the particular user's thinger.io account is provided to only the trusted people by the user thereby keeping personal data confidential and private.

II. RELATED WORKS

Internet of things is a family of interconnected physical devices in their ecosystem that are accessible through the internet based on interoperable information according to Ms. Divya T et.al [8]. IoT devices are used in many fields which make the users' day to day life more comfortable. Internet of Things (IoT) comprises things that have unique identities and are connected to the Internet. The focus on IoT is in the configuration, control and networking via the Internet of devices or "Things" that are traditionally not associated with the internet, Eg: pump, utility meter, car engine etc. IoT is a new revolution in the capabilities of the endpoints or devices that are connected to the internet. It is this capability of internet of things that has attracted its application in the health sector. For example, these smart devices find their application in health sector [2]. The devices collect such data as body temperature, blood pressure, sugar level etc., it is for this reason that this system is being proposed to make use of this phenomena so that the collected data may be used to evaluate the health condition of the patient at remote area and within real time in the light of chronic diseases that have affected an enormous number of people in this era. This system focuses IoT technology in the health sector to make the communication of above mentioned physical parameters of human health possible. This data is then made available to the doctor and other important people to the client, so that accurate decision and necessary actions be taken in time. The cloud platform plays an important role by processing data into intelligible information and provides it to visualizing applications for viewing. The gadgets like a mobile phone, a computer can access the information since the data is available on the internet. Thinger.io a cloud platform provides an inbuilt data analyzing application and a special mobile application using **intel xdk** has been developed for analyzing and visualizing the data on a mobile phone. This mIoT Based Health Monitoring System is therefore not meant for bed ridden patients only, rather it monitors overall human health status in this case even those upright will want to follow their well-being. To achieve all these, this proposed system has been developed after looking into such areas as; 1) analytics applications designs, 2) visualization.

III. PROBLEM DEFINITION & EXISTING SYSTEMS

The current health service available solely depends on the doctor to manually assess our bodies with the sensors. This is challenging because the doctors service ends when one is discharged from the hospital. This means that only those that are at the hospital will have their body status known by the doctor, but how about those that are outside the hospital. It is apparent that one's health has to be checked whether sick or not because we don't know what's happening inside our bodies. This then calls for a system that will be checking the health condition and send the data from a remote distance (wherever the person maybe) to the cloud so that this data can be accessed from anywhere and anytime. Most of the times when our loved ones fall sick we spend much time cheering them not for fun of it, but to see what becomes of their condition with time. This tendency keeps us away from carrying out our daily work that makes the ends meet. This results in economic flaws especially with prolonging illnesses. Lastly, but not least. With the growing industrialization, more people are suffering from chronic

diseases such as heart attack, high blood pressure etc. It is the nature of such illnesses that requires repeated health check-ups at a rate impossible with doctor's manual work. So, having a system doing the work periodically is much helpful and can succeed in having all the body conditions checked and reported in time.

1. **Gennaro et. Al[4].** developed a personal health diagnosis based on the symptoms of the patient. A huge amount of collected data is used to analyze the disease and risk of the patients. Franca discussed that the innovations of the new generation systems are the development of continuous monitoring features for the patient and the improvement of workflows and productivity of medical personal. He also emphasized the various wireless technologies and the advantages of using those technologies for faster communication.
2. **Cristina et. al** developed an approach to maintain health care data of a patient collected in different geographic locations [9]. The data is available to doctors, hospitals, laboratories etc., to check the medical history of the patients. Jieran et al [10]. developed a Radio Frequency Identification technology and intelligent systems, which detect the disinfected articles and alerts the medical staff to wash the hands after the contact with the disinfectant articles.

MERITS

- The existing systems achieved the personal health diagnosis which is carried out based on the symptoms of the patient.
- The system is used effectively in hospital wards and intensive care units(ICUs) to aid doctors in diagnosing a patient.
- The wireless data transfer from one place to the other was made a success.

DEMERITS

- 1) **Confined services to the hospital wards only**
 - The existing systems renders their services only to those people that are in the hospital wards. This creates a problem because once a person is discharged from the hospital, the system ceases to monitor the health status. In cases where one is suffering from a chronic disease that requires a continuous check, there are a lot of challenges.
- 2) **No data visualization dashboards**
 - The existing systems did not provide the data visualization applications thereby by making the data interpretation difficult especially for the layman. Medical data is very important and therefore it has to be presented in a legible and understandable manner so that a user easily understands what is going on with his health status so that necessary actions could be taken. However, the existing systems do not provide this services and allows only the experts to interpret and understand the data trends about one's health status rendering these systems a weakling.
- 3) **Fixed data access platforms**
 - Apart from not having data visualization platforms, the existing system allows one to access data only on the computer that is placed in one location only. This means that one will know his health status if he visits these data centers. This is a weakness on the part of health data which conversely needs to be accessed all the time and everywhere. It has therefore been the area of interest to address this issue so that it is possible to access data from various wearables (phones, pcs, etc.) any time and everywhere with the help thinger.io cloud platform and specially designed mobile applications for visualizing the data.
- 4) **No data access security**
 - As already stated, the existing systems did allow the data to be accessed only by the staff at the hospital. The fresh data straight from sensors could be interpreted into useful information that guides health personnel on what to do next. Therefore, these data are vulnerable to unaccepted access since there is no security means deployed at the data source level to restrict the access to the valid users only and therefore there are problems of medical data leakage which by its nature needs to be treated with caution and integrity.

IV. PROPOSED SYSTEM

The proposed system has to a certain extent strived to solve some challenges that the existing systems are experiencing. There are therefore various areas of improvement with this system and these improvements become the merits of this proposed system as specified below:

1. **Complete IoT architecture**
 - The proposed system will follow a complete "internet of things" architecture which implements security and integrity on medical data access. The thinger.io is a cloud platform account that each user has to sign-up. Every health data from this user via sensors will be uploaded to the cloud through this account and the access to the same is restricted to those having the API address of the account only.
2. **Pervasiveness**
 - The system will be pervasive, servicing those at the hospital and at home. The provision of remote data visualization application and data access mechanisms has completely made it possible that the system be used at homes, home based care to be precise. With this feature in place, people that cannot manage to go to the hospital, talking about the old, children the disabled can still have their body status checked and reported automatically and remotely to those concerned and trusted (doctors and guardians) through the cloud.
3. **Data visualization applications**
 - Unlike the existing systems that do not have the dashboards and data interpreting software, the proposed system will be developed with a data visualizing software to be installed in the mobile. It will be downloading the data from the cloud and interpret it to the user.

V. SYSTEM ARCHITECTURE OF IoT BASED HMS

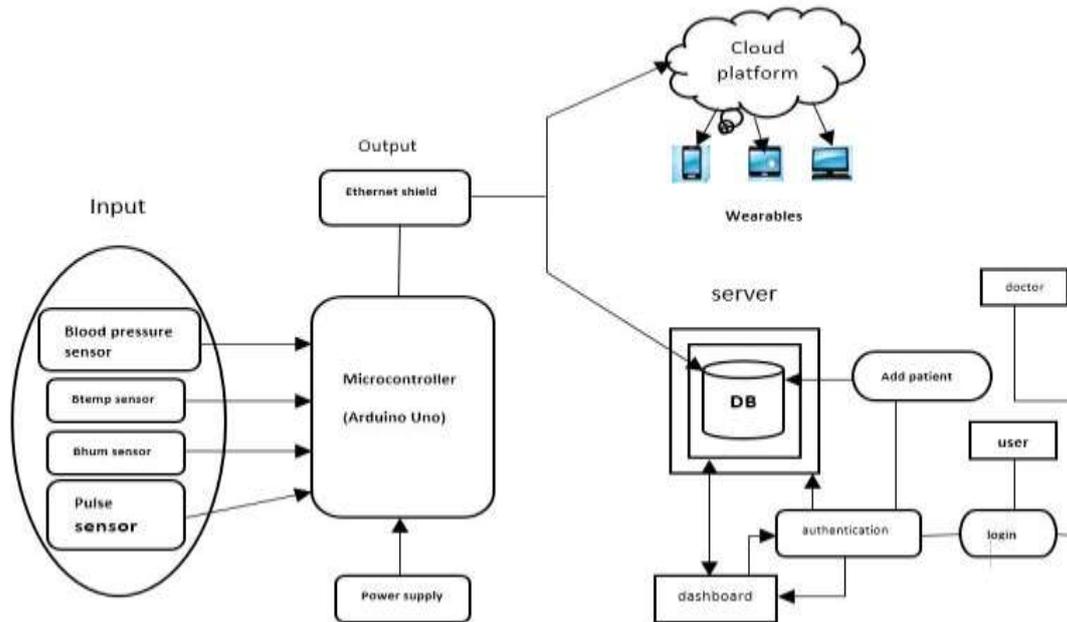


Fig 3.2: System Architecture

The architecture of PHMS contains three phases; they are collection phase, transmission phase, utilization phase. Body Area Network (BAN) is made up of a collection of different sensors and it collects the required data from the patient. The parameters used to diagnose the disease may vary from one disease to another. Therefore, each parameter is sensed by separate IoT devices which are connected to the patient. Blood pressure module, heart rate monitor, temperature etc. are the basic devices used to collect the blood pressure, heart rate and temperature of the patient. The data collected in the collection phase is communicated to the doctor to evaluate the parameter for diagnosis [1]. The collected data is communicated to the doctor through different communication channels depending on the patients' location. The transmission device used in the transmission phases are Ethernet shield. All information collected from the IoT devices is then communicated to the local system which contains the software to check the threshold levels of parameter. The normal minimum and maximum of blood pressure for each age category is shown in Table.1. The average of normal body temperature for the human being is 98.6°F (37°C). This can be measured by the temperature sensor and transmitted to the monitoring system through the wireless device (ethernet shield). The temperature greater than 98.6°F (37°C) will be considered as abnormal. The heartbeat sensor which is connected with arduino Uno microcontroller is used to monitor the heartbeat of the patient as shown in below [1].

DATA ACCESS, VISUALIZATION & ANALYSING

The authorized viewers such as patient attender, trusted relations and the patients can view the details using the mobile application or through the web. The mobile application is accessed by doctors through their user name and password. The doctors can view all the details associated with their clients. Information such as body temperature, blood pressure, heart rate etc. is updated in the cloud server every 60 seconds. If the doctor wants to access any of his client's data he can view it through the web or mobile application that retrieves the information from the cloud server updated by the IoT devices(sensors). Patients, caregivers or any other trusted person can view the data by using the patient or the owner's identification number/Registration number to login and view the details. At critical conditions, the mobile web based application generates notifications automatically. The normal heart rate according to health status research conducted at QUECH is in Table.1

Age Group	Gender	Min/Max (mmHg)
<18	Male	80/120
18 to 20	Male	80/125
21 to 40	Male	85/135
40 and above	Male	85/135
<20	Female	80/123
21 to 40	Female	85/133
40 and above	Female	85/133

Table 1: the heart rate threshold levels

VI. SYSTEM DEVELOPMENT

A system is made up of a collection of segments called modules. The linking of these segments gives a form to the entire system which also further defines the functionality of the whole system. In this system, these modules have been categorized into two, namely Hardware modules and software modules since the system is embedded. Below is a list of all the modules and their descriptions:

SOFTWARE MODULE

1. Security module
2. User Management Module
3. Report Module
4. Data Visualization Module
5. Networking Module

1. Security module

This module is accomplished by the login form that requires the user to enter his credentials before accessing the system's services. The credentials include a valid password and the user name. The credentials are checked for validity, if the credentials are valid the access to the services is granted and if not the user is not allowed to proceed by continuously asking the user to enter the credentials. This provides security since only those who were registered into the system database will be allowed to access the system services.

2. User Management Module

This module allows the administrator or the doctor to add new users to the system. Since the system can cater a number of user at a time, there is always a chance that new user might want to be added to the system. The task of adding new user is done by the system administrator or the doctor. He manages or the users old and the newly added users to the system through this module.

3. Report Module

An Electronic Health Report(EHR) about how the user's body conditions have fared for a particular period of time is recorded and presented as a report specifying the date and time of body checking activity and their corresponding values. The report may then be downloaded or printed for further reference and all these services are possible with the system's report module.

4. Data Visualization Module

A specially designed chart on the dashboard and the gauges on the mobile application interprets the data for the user to easily understand the trends of the human body values at particular period.

5. Networking Module

The Ethernet shield is the one that transmits sensorial data from the microcontroller to the thinger.io, the cloud platform.

HARDWARE MODULE

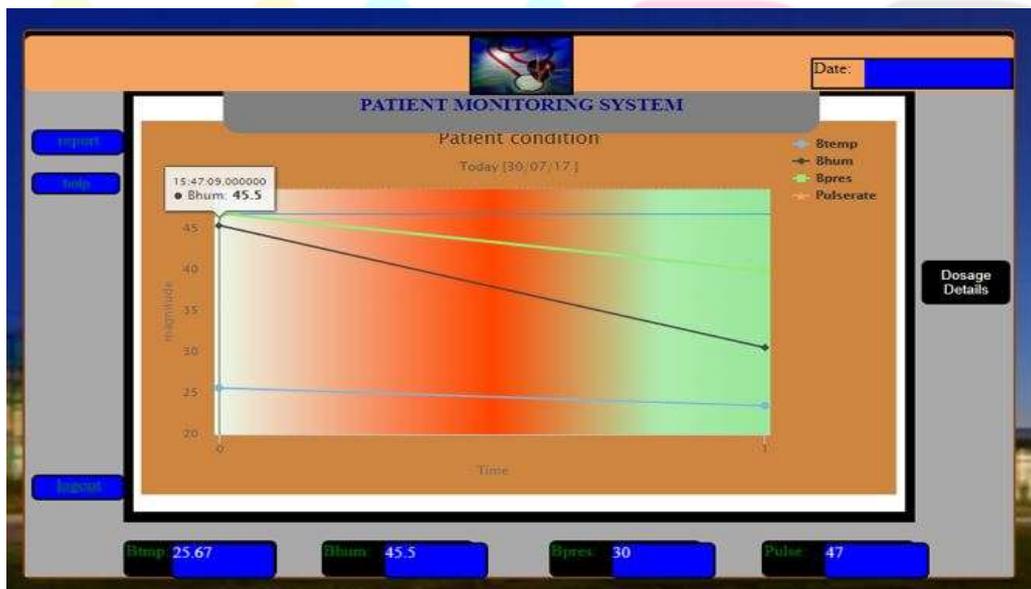
1. Sensing Module
2. Control Unit

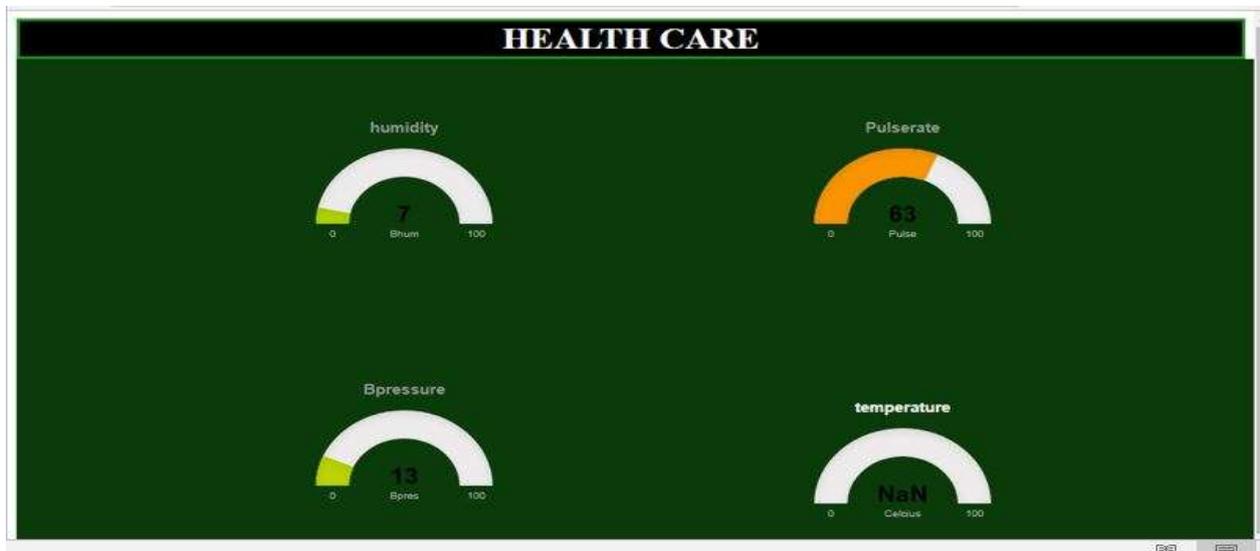
1. Sensing Module

Sensors senses the body and collects data about conditions and transfer the data to the microcontroller for processing. The microcontroller through the Ethernet shield then uploads the data to the cloud via a thinger.io account.

2. Control Unit

The control unit of a system is concerned with decision making and coordination of every system functionality.in this case the microcontroller is the control unit. Arduino Uno has been used to process data and send the same to the cloud for reference.

VII. RESULT



VIII CONCLUSION

IoT as an imaging technology has proven to be a promising technology in the health sector. The communicating devices in the absence of a human being intervention has enable the IoT devices to communicate real time health related information with much needed decision. The information can then be accessed from anywhere and can serve as basis for decision making by the medical practitioners and other caretakers. This technology can successfully terminate unnecessary death due to negligence by the health practitioners as well as providing timely body status condition so that appropriate actions are undertaken by both parts.

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