IoT BASED HEALTH MONITORING WEARABLE DEVICE USING SECURITY MECHANISMS FOR STORAGE

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Abstract*—Medical science has been moving forward at a rapid rate, so as the cost of affording the health care. Time has witnessed an exponential increase in health care costs in the last few decades. In order to get the vital signs tested, people have to make frequent visits to the clinic. The objective of this project is to design and implement a reliable, cheap, low powered, and accurate system that can be worn on a regular basis and monitor the vital signs and displays the parameters like the pulse rate, body temperature and minute flow rate of respiration to the user's cell phone. The data will also be easily accessible by the physician through wireless networks. This project specifically deals with the signal conditioning and data acquisition of three vital signs: heart rate, respiratory patterns, and body temperature. With this project, we propose a system for monitoring of heart rate, the body temperature of the person with dedicated sensors using microcontroller Arduino UNO R3 along with respective sensors. The system is coded into Arduino IDE. A perfect tradeoff between accuracy and cost of the system is accomplished by choosing appropriate sensors which are DS18B20 (temperature sensor), SEN-11574 (pulse rate sensor) and, ADS1292R (respiratory sensor). The pulse rate and temperature of a person along with respiratory patterns are measured at different time instants by the sensors. The data will be stored in cloud storage using symmetric key cryptography algorithms such as AES, and BR-Algorithm. The data then can be retrieved using three-step cipher text data retrieval method DES or step-by-step RSA algorithm, to a wireless-enabled mobile device/display device using a unique identification technique.

Keywords— Algorithms, Arduino UNO R3, Cloud Storage, Health Care, IOT, Network, Services

I. INTRODUCTION

The "Internet of Things" – IOT is a concept based upon a microcontroller with a range of different sensors, actuator and development boards interacting with each other over the internet to record and produce useful information with little or no human intervention. In laymen term, IOT refers to a network of anything, anytime, anyplace and any service all connected to each other producing plethora of useful information that can be accounted and analyzed for various purposes. [1] In the healthcare domain, IoT is changing the way care is provided and managed, via data and information exchange between connected and wearable devices.

The IoT has enabled a more tailored form of care where consumers are self-managing and self-monitoring their own health. Wearable technology has made significant progress in recent years. A larger population is being shifted towards wearable monitoring devices for continuous monitoring.

Although wearables have benefited from advances in mobile technologies, functionality remains limited compared to smartphones. However mobile phones are impractical to carry anywhere, anytime which gives rise to wearable technology. The IoT is a potential emerging solution that consists of devices which are interconnected to produce meaningful data.

II. BACKGROUND

Health care is the most important perspective of a developed county. A country can only be termed as a developed country when each and every individual is able to afford proper health care. A remote health monitoring system can help individuals, especially senior citizen's to keep a check on their health. A wearable device is the easiest way to carry your health check-up anywhere, without depending on regular appointments and to remember them. A Health monitoring system as of now has either only sensors along with a microcontroller to measure the data. [2] Or in the researchers where the sensors are used as wearable ones have not included all three sensors along with a storage capability. Where the storage capabilities are used, the concern of security of user's data has not been kept as a consideration. The storage and retrieval of data are considered with a limited cloud mechanics, which has its own drawbacks.[3] The data are thus when used as an independent source along with a good security mechanism can render better results to a patient and doctors who retrieve the data for analytic purposes.

III. RELATED WORK

The existing systems have used IOT for health monitoring systems which are elaborated below,

Zimu Li et al [4] proposed a system where the monitoring records can be checked by doctors to serve a bigger population who are not in the hospitals. This will bring the doctor and patients closer to each other.

Salman Ahmed et al [5], the range of the area covered is smaller and hence makes it less useful. There is no system proposed to store the data efficiently.

Kahtan Aziz et al [6] proposed a smart system to overcome diseases and illness like Alzheimer and motion patients can also be benefited by this system.

Sarfraz Fayaz Khan et al [7] proposed a system where body area network is used and smartphone transfer is implemented to transmit important data. The smartphone electronic compatibility has a huge scope in future keeping security at the stake.

Manisha Shelar et al [8] uses a new transfer technology using ZigBee. Although, the abnormalities in the patient is informed through SMS itself. Xbee-pro RF module is used for wireless connectivity.

Deepesh K Rathore et al [9] proposed a system where a message will be directly sent to a nearby doctor when there are some abnormalities, the patient's information with address will be sent to the doctor.

Himadri Nath Saha et al [10] puts a light on the drawbacks of an ivory display which does not focus on two-way communication. The health-related info can be sent to WHO in places where there is a scarcity of doctors

IV. PROPOSED SYSTEM

This system includes a 3-protocol layer as shown in fig.1 where each layer contributes and when combined a successful monitoring system is achieved. The base layer contains the device layer followed by network layer and application layer. The device layer contains all the connections required among the sensors and the Arduino board such that efficient data is collected from the user. The network layer explains the networking between the cloud/internet and the device. The Byte Rotation Algorithm and Advanced Encryption Algorithm is used in this layer to maintain security and efficiency of the data when transferred between the device layer and the application layer. The top layer is the application layer that contains the user interface where the data is stored in the database and also be available to the user whenever required.

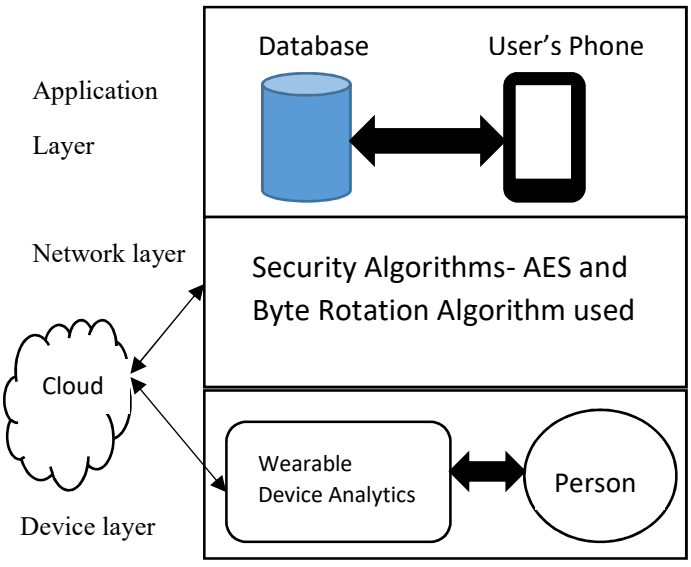

Fig.1: Components of the system

A. *Benefits and Impacts:*

The system provides a portable device which will be handy to the user and will keep a timely check on the health of the person. This data collected by the device will be stored onto the cloud so that the data can be retrieved whenever required. The usage of AES and BRA ensures the data is stored and retrieved from the cloud securely.

V. SYSTEM ARCHITECTURE

The system architecture is divided into two major segments,

- Hardware Segment
- Software Segment

A. Hardware Segment

The hardware segment has a microcontroller Arduino UNO R3, temperature sensors, a pulse rate sensor and a respiratory sensor and an ESP8266 Wi-Fi shield.

1) Arduino UNO R3

Arduino Uno is a computer hardware which is basically a microcontroller board based on ATmega328. The Arduino Uno has 14 digital I/O pins out of which 6 can be used as PWM outputs, 6 analog inputs, a 16MHz ceramic resonator, a USB connection, a power jack and a reset button. It operates at 16MHz clock speed. It has an SRAM of 2KB and EEPROM of 1KB. Arduino has a flash memory of 32KB out of which 0.5KBis used by bootloader. In addition to this, the Arduino Uno can be easily coded by using Arduino IDE.

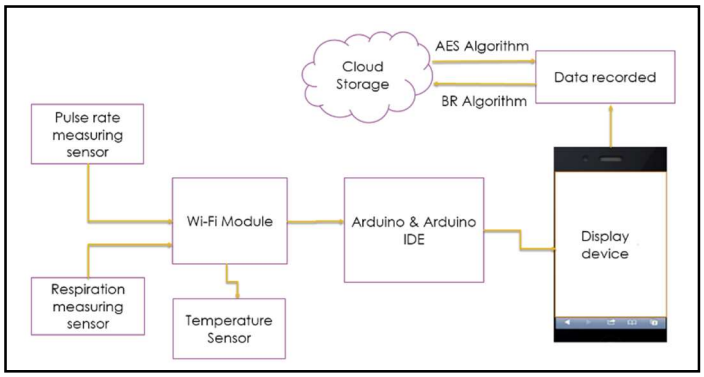

Fig. 2 Schematic Diagram of System

2) DS18B20 - Temperature Sensor

The DS18B20 digital sensor or can be termed as a thermal probe that employs DALLAS DS18B20. This temperature sensor is favorable because of its unique one wire interface. The conversion time of an analog signal to a digital signal is as much less as 750 ms. It can convert temperature to s 12-bit digital word. It has waterproof capabilities which make it apt for a wearable health monitoring device.

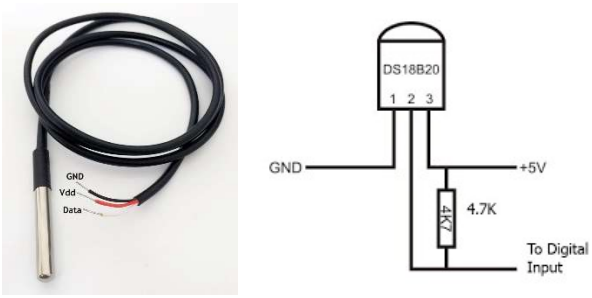

Fig 3. A schematic representation of DS18B20

3) SEN-11574-Pulse Sensor:

The pulse can be defined as the number of times the heart beats per minute. This pulse rate must be maintained by the heart in order to ensure a healthy body. Whenever a person falls ill there are changes noticed in their heartbeat. So it is important to monitor the heartbeat of the person. This is done by achieving pulse sensor SEN-11574. This pulse sensor is a plug-and-play heart rate sensor for Arduino and other microcontrollers.

Fig 4. SEN-11574 pulse sensor

4) ADS1292R- Respiratory Sensor

AD1292R respiratory shield for Arduino reads the ECG and respiration data in real time processing. It has an SPI pin which makes it compatible with most of the microcontrollers. The cable of the sensor takes two ECG electrodes and one DRL (Driven Right Leg) electrode which works for common mode noise reduction. The ADS1292R uses "impedance pneumography" to

measure respiration. The methodology is the change in chest impedance to arrive at respiration measurements.

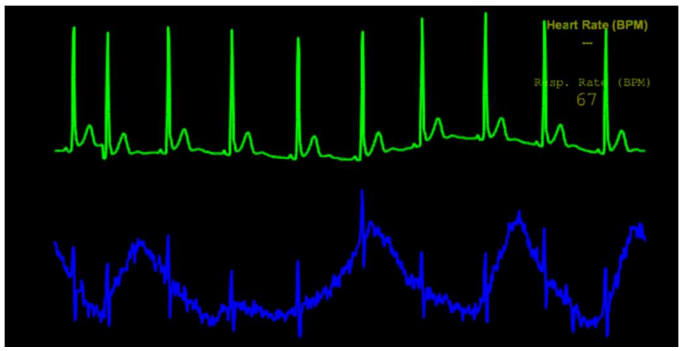

Fig. 5. Schematic readings of the ADS1292R sensor

B. Software Segment

1) Arduino IDE

Arduino IDE is an Integrated Development Environment for Arduino driven processing. Arduino IDE is user-friendly and efficient for development of programs. It acts as an interface between all the hardware components of the system. It is compatible with a wide range of programming languages. It is a powerful base for any developmental processes which includes Arduino and are carried out by Researchers, Development Professionals, and programmers. It is an open source software which can be used to work on Windows, Linux, or Mac Operating System. The Arduino IDE takes the readings of sensors from Arduino board and displays it to the user. Various algorithms can be applied using IDE and programming languages to make health predictions.

2) Cloud Storage

Cloud Storage space is used to collect data from Sensors and store it. The data is stored using Bite Rotation Algorithm and can be retrieved anywhere using AES Algorithm which enables only an authorized user to access data using a unique identification and password technique. Variously paid cloud storages are available, such as AWS, IBM Bluemix, Google Cloud, iCloud by Apple Inc.

3) AES and BR – Algorithm

A. Byte Rotation Algorithm

Bite Rotation Algorithm (BRA) is used for secure data transfer. It enhances the data security. It supports OS concept of multi-threading. A thread is a small block of a program/execution unit. It allows execution of multiple threads within a single process. It is a symmetric Key Block Cipher Algorithm. It has each block size is of 16 bytes. The size of the key matrix is 16 bytes, and the values of the key matrix are randomly selected which ranges from 1 to 26. It follows Monoalphabetic substitution concept. The BR Algorithm takes less time to create a new thread than a process. The termination of the thread as well as the time to switch between threads is also less. Threads within same process share memory and other resources, they can communicate with each other without invoking the kernel. It is fast compared to other algorithms and thus makes it much useful. It provides better security and involves no complex calculations.

B. Advanced Encryption Standard

Advanced Encryption Standard (AES) is a symmetric key algorithm. The data is available as 128-bit and the keys are of 128/192/256-bit. It is an iterative rather than a Feistel cipher. It is stronger than triple DES and can be implemented using Java or C language. It is based on the substitutive-permutation network. AES performs all its computational operations in bytes and not in bits, which makes it efficient and fast. The security mechanism of data storage and retrieval makes is appropriate for usage. As the user data integrity and security is a major concern.

VI. METHODOLOGY

The main objective of health monitoring system must be that should be serviceable hence they need to be user-friendly, easy-to-use and light in weight. It must be low powered, light weighted and small in size. The system is made cost effective by using a small, low powered microcontroller Arduino Board as shown in fig.1. Our system consists of DS18b20 temperature sensor that is used to measure the body temperature. The SEN-11574 pulse sensor is used to timely measure the pulse rate of the heart by placing the sensor on the fingertips. ADS1292R is the respiratory sensor which is a flow-based LME and LDE differential pressure sensor that operates on the principle of thermal mass flow. The output of the temperature sensor is digital in nature so it is connected to pin 2 of the Arduino board. The SEN-11574 is connected to pin 0 of the board as the pulse sensor generates analog signals. Similarly, ADS1292R is connected to pin 1. This Arduino board is connected to the Wi-Fi and the sensors are coded accordingly by using Arduino IDE. The sensors will collect the data timely and will store it in the

cloud. The data can be easily transferred and retrieved from the cloud using Byte-Rotation Algorithm and Advanced Encryption Algorithm. Each user will be able to create an account by entering the username and password which will ensure the security of data. These data can be easily accessed by the doctors to analyze all the parameters from the cloud.

VII. EXPERIMENTAL SETUP

The experimental setup is a working prototype of the system as shown in the fig (6) the desired sensors are connected to the Arduino Board at the assigned pins in order to track the output signals.

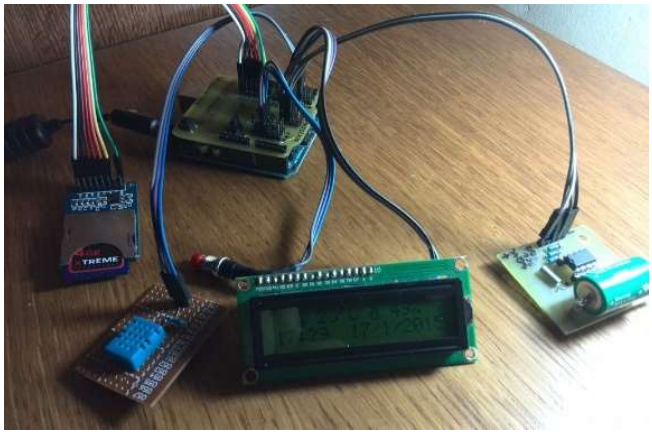

Fig 6. Experimental Setup

VIII. MATHEMATICAL ANALYSIS

A large amount of data which is being collected by the sensors can be used to predict various health issues, which are generally rare to be diagnosed easily. One such disorder is Sleep Disordered Breathing (SDB). Recent studies have uncovered high prevalence of undiagnosed SDB and its linkage to metabolic or cardiovascular disorders which represent an increasing health hazard.

The governing equation of the model that has been shown in Fig.7

$$y = SKy^R + V^{-1}\big(D - diag(D^T e) + Q - diag(Q^T e)\big)y + s(y)$$

Representation of terms in the equation:

SKy^R: Chemical Reactions

$D - diag(D^T e)$: Diffusion Terms

$Q - diag(Q^T e)$: Blood flow terms

$s(y)$: Sink and source terms

The above equation can thus, predict the sleep disorders and can help the physician to keep a track on patient's SDB record.

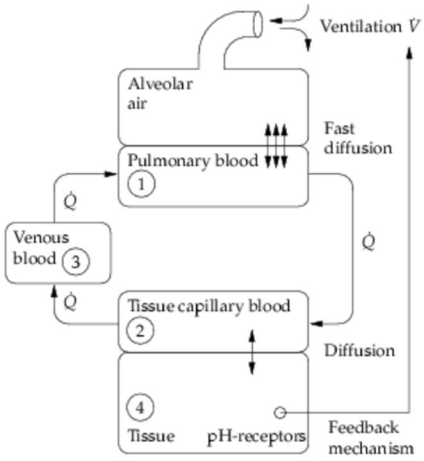

Fig 7. A schematic of the human respiratory control model

IX. RESULTS

The fig (8) shows the flow diagram of the system representing the sequence in which the operations are performed.

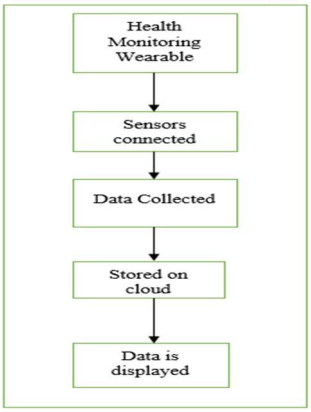

Fig. 8: Flow Diagram of the system

The various changes are observed in the pulse rate while a person is doing various activities which can be recorded by the system as shown in the graphical representation of the fig (9).

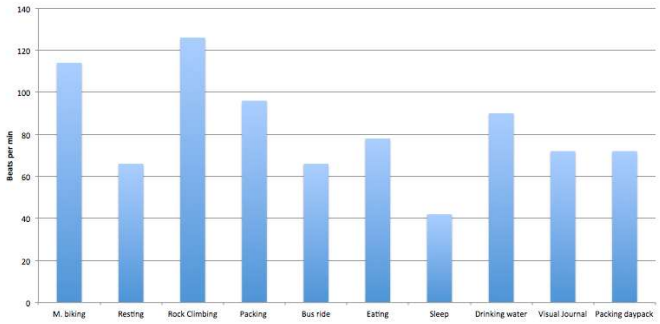

Fig. 9: Variation in pulse rate with time

The human body temperature changes throughout the day varying from person to person. If the temperature rises above this normal level it can be easily concluded that the person is sick. Fig.10 shows the graphical variation in the body temperature throughout the day.

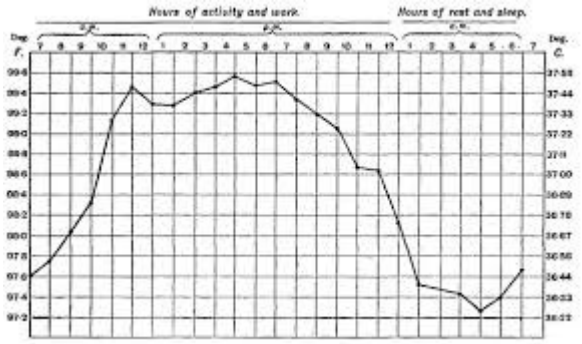

Fig.10: Variation in body temperature throughout the day

The fig. 11 shows the breathing rate patterns depending upon which the health of the person is determined. If the person breathes 18 times/min it indicates that the person is sick and if the person is breaths more than 30 times/min it indicates that he is severely sick.

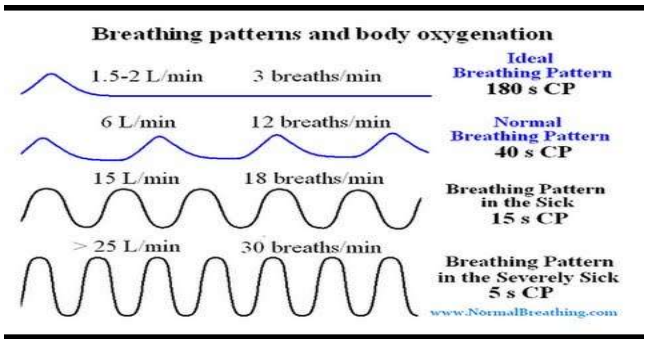

Fig.11: Breathing rate chart

One of the values of the temperature has been shown in the fig (12). This notification will be shown when the body temperature rises above 90 degrees.

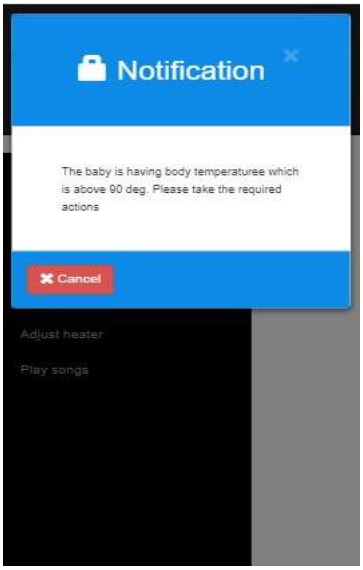

Fig. 12. Parameter generated

X. CONCLUSION AND FUTURE WORKS

The proposed system provides an efficient, affordable, user-friendly and portable health monitoring system. The data collected by sensors are stored securely in the cloud storage and thus, it can be easily accessible anywhere, anytime and by anyone who has access rights. The system uses a microcontroller Arduino, three sensors and a cloud storage with all the components connected to the internet. Which makes it easy to operate and less complex. The user can get vital signs check on a regular basis using this system. Which makes it one of the best companion of a healthy life.

By adding a technology which will analyze data and predict sleeping patterns of the user, and give suggestions of a nearby clinic which are open at the required time and, a set of pharmaceutical shops which are in and around a radius of 4 KMs of the user. The system can be transformed in to complete health assistant.

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