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Research Paper

MediKit : IoT Based Smart Healthcare System for Effective Supervision of Patient

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Abstract

Medikit - An IoT healthcare system is developed for patients, hospitals and care centers that regularly supervise the health condition and checks whether the patient has taken the prescribed medicine. The proposed work monitors patient's vitals such as pulse rate and body temperature on real time basis. Such information will be used by the doctor to diagnose the patient remotely and prescribe optimum medication dose. Further, the Medikit system apart from collecting the data ensures that patient has taken the medicine on time. For the proposed system the authors have used Bluetooth Technology to send sensor data to a Smartphone and also to Cloud Service Platform for archiving and analysis. The information available on the Cloud can be supervised by the doctor by using a Mobile application. The mobile application also supports scheduling of medicines as per doctor's prescription in the medical box. The comprehensive system developed, to the best of author's knowledge, is low cost, efficient and service oriented as compared to the traditional healthcare practices and other eHealth solutions discussed.

Keywords: *Cloud Computing,;Internet of thing (IoT);Sensor Technology;Smart Health Care System*

1. Introduction

Internet of Things (IoT) expands the Internet into our everyday lives by wirelessly connecting various smart objects and will bring significant hangs in the way we live and interact with smart devices [1]. The new wave in the era of computing will be outside the sphere of the conventional desktop. As compared to previous automation technologies IoT has emerged as a disruptive technology that enables high integration of human connectivity with objects. The IoT assent has been rapid in many areas that mandate usage of smart objects to improve quality of life and increase profitability either by reducing energy cost, optimizing workforce or preventive maintenance. IoT applications has exceeded beyond the traditional Machine-to-Machine (M2M) scenarios and impacted whole new business spectrum that includes Smart city & building, Smart Agriculture, Healthcare, Environment protection, Logistics and many more. The interconnected objects collect the data at regular intervals, analyze to generate knowledge and initiate required action. The IOT is generally considered as connecting objects to the Internet and using that connection for control of the objects or remote monitoring [2].

The presented work addresses the Healthcare application area of IoT by proposing a comprehensive smart cost effective working model. Currently, worldwide with increase in the aging population and the need to provide immediate preventive care has inundated the responsibilities of care centers and hospitals. Numerous countries are undergoing hospital restructuring by reducing the number of hospital beds and promoting home healthcare, which is envisioned to improve health care cost with emphasis on quality. This trend relies on adding intelligence through sensors (RFID) that are the data provides, embedded computing resource (Motes, NodeMCU, Bio implanted devices), wireless technologies with tailored combination networks (Bluetooth, Zigbee, GSM) and web or cloud services for archiving, scheduling and processing workload results for right diagnosis.

An IOT enabled healthcare system not only monitors real time vitals of a patient but also renders services in the following areas: tracking people and biomedical devices, drug dosage, inventory control and early detection of clinical deterioration. Further for next level of decision process the IOT based smart healthcare system takes assistance from efficient image processing, machine learning, Security assignment and predictive algorithm models. [3] Discusses the reasons for emergence of IoT and the design of applications where IoT is used. With changing lifestyle the issue is people no time for regular health checkups or maintain track of their progress for ongoing treatment. The answer to such problem is empowering devices to collect information on their own, without any human interference. IOTapplication in healthcare requires fulfilling five key characteristics - stability, continuity, reliability, efficiency and security. By engaging smart healthcare system accurate and timely decisions for diagnosis and treatment can be taken so that unnecessary wastage of precious time can be avoided. The concept of smart healthcare system is to enable services to anybody at any time.

2. Existing smart healthcare systems

With incorporation if Information and Communication Technologies (ICT) Health care industry has evolved as electronic Health to address the problems of reducing delay in delivering

diagnostics procedures and treatments, tracing patients records, updating prescriptions by checking the vitals in real-time. The new paradigm in e-Health is the incorporation of mobile technology with sensing and networking infrastructure with context aware environments. The global e-Health for 2014 was valued at USD 85.44 billion and expected to reach USD 308.0billion by 2022 [4]. The report also highlight key segments like e-Health diagnostics to increase by 15% over next seven years and Mobile Health market to increase by 24% by 2022. Thus indicating higher market growth in smart health care systems.

Future ready Smart Healthcare systems are required to deliver round the clock service through a centralized healthcare chain that is self-monitored and maintained reduces medical errors and provides faster access to patient's vitals & records. This section discusses the various architecture frameworks and topologies proposed for realizing smart healthcare system.

[5] Proposes the Smart HealthCare Architecture framework named BCEP Care that works on complex event partitioning and clustering algorithms to improve the performance of large scale IoT Based Healthcare application. The work described proposes to reduce the complexity and optimizes the event to reduce wastage of system resources in real time as compared to Esper model. The process involves following steps – 1) Decompose CEP and generate number of sub-events, 2) Determine correlation among the sub-events and finally 3) using the clustering algorithm eliminate the duplication and achieve work load balance.

[6] Proposes Smart Hospital System (SHS) based on RFID, WSN and smart mobile interoperating with each other through CoAP/6LoWPAN/REST network infrastructure. The proposed work is able to collect real-time variation of any critical patient's physiological parameter as well as environmental condition. The three main building blocks of SHS are 1) RFID enhanced WSN - the underlying Architecture that supports all major functionalities namely Hybrid Sensing Network (HSN), 2) IoT Smart Gateway – in charge of data collection and processing, system management and service execution and 3) User Interface- permits authorized user access via web browser by both fixed workspaces and mobile services. The paper introduce IOT HEALTHCARE to provide improved patients monitoring and diagnosis for shifting toward prevention and early detection of disease and those who want intensive monitoring for health conditions. Implementation of IoT healthcare is divided into five key characteristics: Stability, continuity, confidentiality, reliability and efficiency must be applied to the smart healthcare system to reliable the features of the IoT.

[7] Discusses IoT as an intelligent collaborative security model for smart healthcare system that integrates allied technologies like wearable devices, Ambient Assisted Living (AAL) intelligence and big data. The AAL addresses the healthcare issues of aging and differently abled individuals by having a modular architecture that is based on automation, security, control and communication. This enables effective service to the elderly individuals, caregivers, physicians and family members. Internet of m-Health Things (m-IoT) integrates mobile computing, medical sensors, and communication technologies using 6LoWPAN.Its application includes sensing of glucose levels.

[8] The paper presents two mobile cloud enabled body sensors for healthcare applications 1. Ingestible miniature device, Wearable Capsule Endoscope (WCE), is employed to inspect gastrointestinal tract where in image frames are transmitted to cloud for further processing and enhance diagnostic function, 2. Wearable devices for continuous and long –term monitoring of Electrocardiogram (ECG) and Photoplethysmogram (PPG) by Ag-Ag/Cl electrodes and infrared sensors and further utilizing cloud storage resources.

[9] Employs fog computing for healthcare application, wherein network components between the physical device and cloud are utilized to execute specific logic. The advantages of the system are: i. reduced latency, ii. Improved privacy as unnecessary data propagation is reduced to cloud, iii. Improved energy efficiency, iv. Reduced bandwidth requirement as raw data is filtered, analysed, pre-processed or compressed, v. improved scalability as local computation reduce the load on centralized resources, vi. Increased system dependability, and vii. Enables context based decision and reduces unnecessary activity.

3. Proposed system.

3.1. Features of Proposed System

The proposed system includes the following features as shown in Fig. 1.

a. Real-time supervision and analyses of patient's health condition and early-detection or diagnosis of life threatening events.

b. Mobile application for doctor to monitor the patient vitals and gets notifications when these exceed certain limit.

c. Checking whether the patient has taken the prescribed medication on time.

d. Monitor drawing of medicines from the MediKit at scheduled time.

e. Medical alerts to care taker and doctor.

f. Online report generation of medicine consumption.

g. Generating real-time visuals that represents patient's vital statistics.

h. Programming the Medikit by sending configuration data (prescribed medicine schedule) through mobile application.

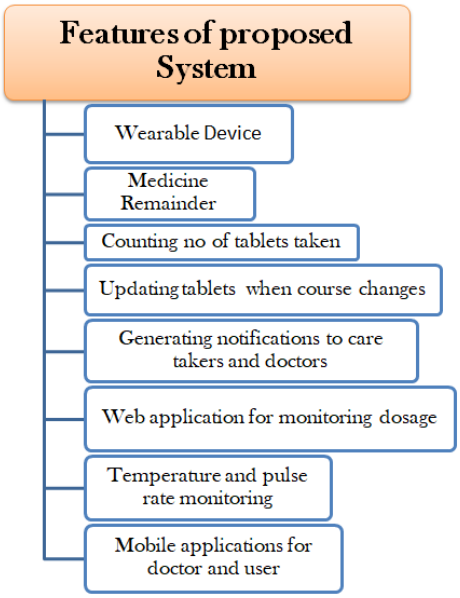

Fig. 1: Features of proposed system

3.2. Wearable Device

The proposed system is to guarantee that the patient is managed by the doctor at any conceivable time with the end goal that well-being condition is looked after appropriately. A wearable gadget has been developed which are being interfaced with pulse sensor and temperature sensor to Arduino Nano so that the information is

sent to Smartphone through Bluetooth which is associated with Arduino through Serial communication. The information sent is received by the Smartphone through remote communication (Bluetooth) and is uploaded to cloud through Wi-Fi or GPRS as appeared in Fig 2. For this a versatile application is built with the end goal that the doctor can monitor the condition and can make a move when there is any dangerous trouble situation.

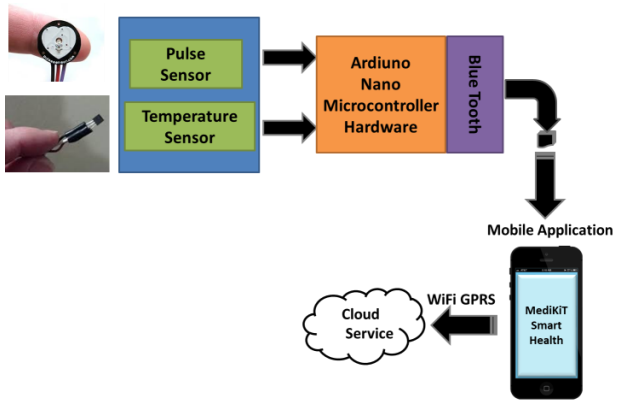

Fig. 2: Functional Block Diagram of Wearable device

ThingSpeak cloud platform is used to store the data which is obtained from the sensors .A Mobile App has been built for the doctor using MIT app inventor which monitors the conditioning of the patient and alerts him whenever there is a critical condition.

3.3. Smart MediKit

The proposed system also includes a MediKit as shown in Fig 3 which ensures that the patient consumes medicines as per schedule time table. This MediKit contains Node MCU - Programmed hardware platform, Multiplexer, LEDs, Buzzer, Reset Button and Configuration Switch.

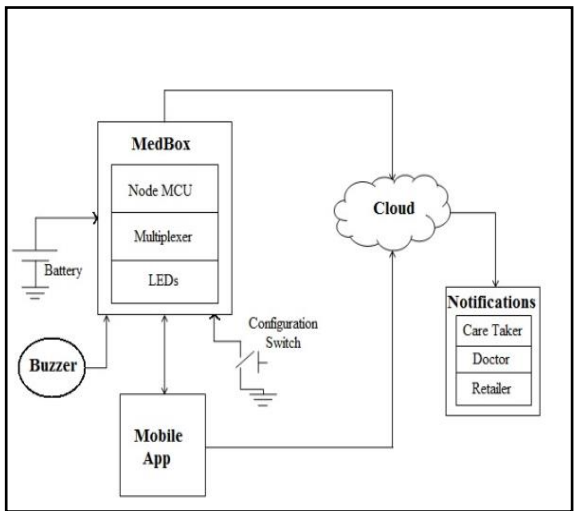

Fig. 3: Block diagram of Smart MediKit

The medicine prescription schedule also termed as configuration data for the hardware is send to the MediKit using Mobile App which then sends data through IP address generated by NodeMCU. The weekly schedule which is configured in mobile app is also sent to cloud platform so that the doctor knows whether the same schedule is followed. The multiplexer are used to connect LED's in MediKit by NodeMCU. NodeMCU is inbuilt with Wi-Fi module.

The Wi-Fi module is configured as MEDIKITAP, such that the IP address is generated in local network. By pairing the MediKit IP address generated by MEDIKITAP to the Mobile App. The configuration data is send to the smart MediKit when the configuration is in ON mode. The configured LED glows with buzzer at schedule time.

The configuration data from Mobile App is send to the EEPROM with an IP address and to cloud platform. The configuration data checks with the Real time and matching data will respond to the glow of LED and Buzzer. By resetting the button the tablet details are uploaded to the cloud platform and excel sheet is provided to know the consumption detailed number of tablets consumed by a person. If the person or elderly people doesn't reset button at schedule time the alert/SMS is send to the user.

3.4. Benefits to Stake Holders

The major stakeholders in the proposed system are patients, Doctors, pharmaceutical firms. The doctor can be able to monitor the patient at any time even though the doctor is not available near the patient. The presence of doctor at patient can be avoided. Patient can get immediate assistance from the doctor as the doctor gets notified about the condition of the patient. The proposed system benefits the patient by ensuring them whether the patient has taken medicine on time, so that the dose given by the doctor is followed correctly. Scheduling of medicine can be dynamic so it makes flexible for the doctor and the caretaker to change the dose or medicine. Pharmaceutical firms gets notified regarding the shortage of medicine and can get medicines on time.

4. Implementation

4.1 Software Tools

The software tools used for the implementation of the proposed system are

- Arduino IDE
- Android Studio and MIT app inventor for development of mobile applications
- HTML and PHP for development of cloud and web application

4.2 Flow chart

4.2.1 Wearable Device

The below flowchart represents the execution flow of smart health wearable device Fig 4.The Bluetooth interfaced to Arduino Nano need to be connected to Bluetooth of Smartphone .A mobile application (user app) isbuilt to receive data from Bluetooth .Then the sensor data is received by the Smartphone and it's been sent to the cloud if it is connected to Wi-Fi or GPRS .The Data is stored in the cloud and is been visualized graphically]. A mobile application (Doctor App) is built for the doctor to monitor the patient condition which is retrieved from cloud .If the body temperature or pulse rate increase then a notification is sent to the care taker or doctor so that immediate action would be taken.

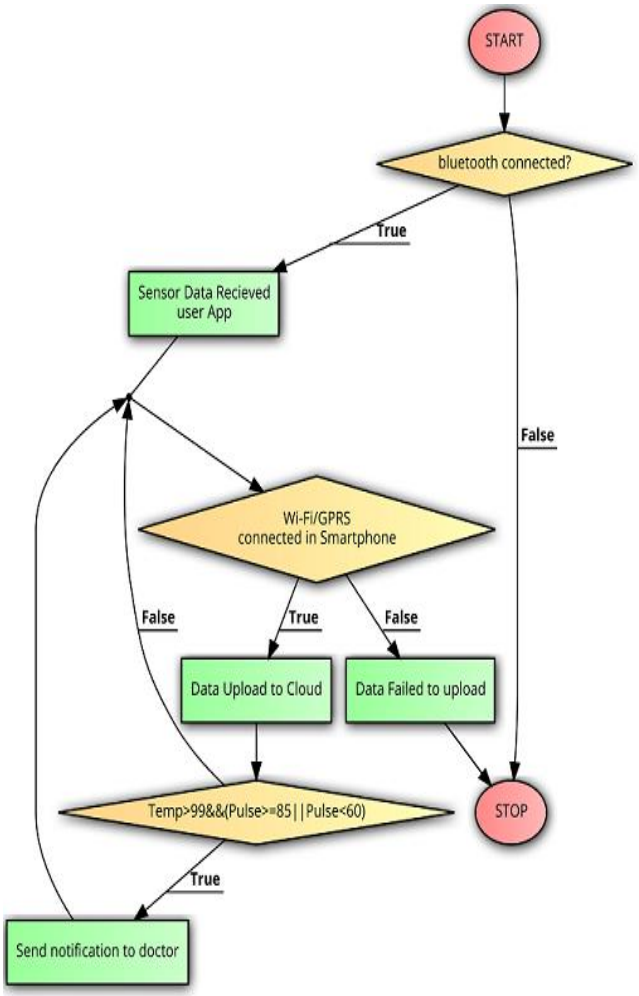

Fig. 4: Flow chart for Wearable Device

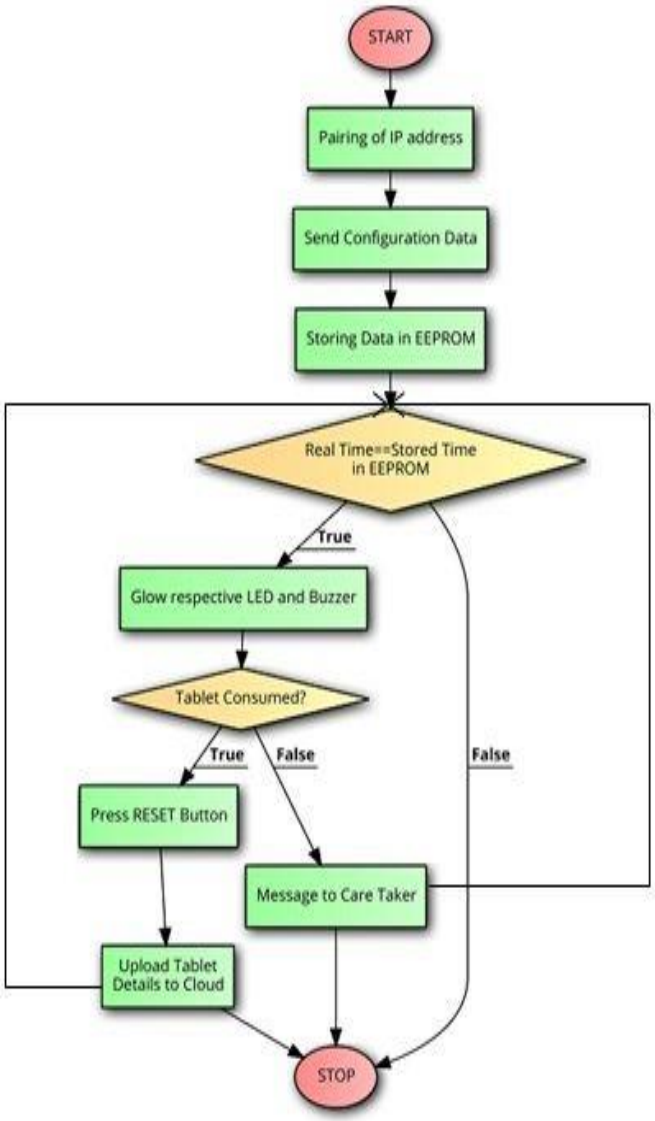

Fig. 5: Flow chart for Smart MediKit

4.2.2 Smart MediKit

The below flowchart represents the execution flow of smart health wearable device Fig 5. MediKit contains Led lights arranged as per schedule per week. The Doctor Prescription or consumption details are given to the MediKit through Wi-Fi from Mobile application. In Mobile application it creates a hotspot to manage MediKit Wi-Fi and generates IP address of the local network. The consumption details are sent from Mobile application to the MediKit by the IP address.

The obtained data is stored in EEPROM of NodeMCU which includes Time and prescription medicine details. Whenever EEPROM time meets with the real time then a buzzer and respective led glows which intimates the patient regarding the tablet by pressing the push button the consumption details are uploaded to the cloud platform. If the patient doesn't press the reset button then a message is sent to care taker. The tablet count and consumption timings and dose is maintained in the cloud and is obtained in the form of excel sheet.

4.3 Deployment Layers

Deployment scenario in the proposed system is shown in the **Fig 6**. Deployment layer consists of PAN/BAN, LAN, WAN, CLOUD. Devices are used in different network layers.

PAN/BAN: Personal Area Network/Body Area Network. This layer includes the devices or sensors which are connected to the body or connected to Personal Area Network .The proposed smart health monitoring consists of Bluetooth module which is connected to wearable device. Sensors are connected to wearable device. Using BLE communication wearable device is connected to Smartphone.

The proposed model includes MediKit it consists of NodeMCU which generates its own Access point. The IPgenerated is used by the Smartphone to connect with NodeMCU. Prescribed Medicine data is sent to NodeMCU and is stored in EEPROM.

LAN: The proposed system does not include LAN.

WAN: The Smart health Monitoring uses Smartphone as its gateway to send the data to cloud .It can be Wi-Fi or GPRS connectivity. A mobile phone acts as mobile base unit and collects data

from several sensing devices, processes it and sends it to a back end server.

The MediKit unit is connected to Gateway using Smartphone through Wi-Fi communication. The gateway is also connected with MediKit with the help of NodeMCU .The transfer of data takes place between the device and cloud is through gateway. The gateway uses different protocols to transfer data. The proposed system uses HTTP protocol to communicate with the cloud platform.

CLOUD: The proposed system uses Thingspeak cloud platform to store data and visualize data. Mobile Application built in the Smartphone communicates with the cloud using API keys which are unique for every user. The Stored data is retrieved back to doctor application using read API keys which are available in the cloud platform. The proposed system also uses a services called REACT to generate notifications to the doctor whenever the patient vitals are high.

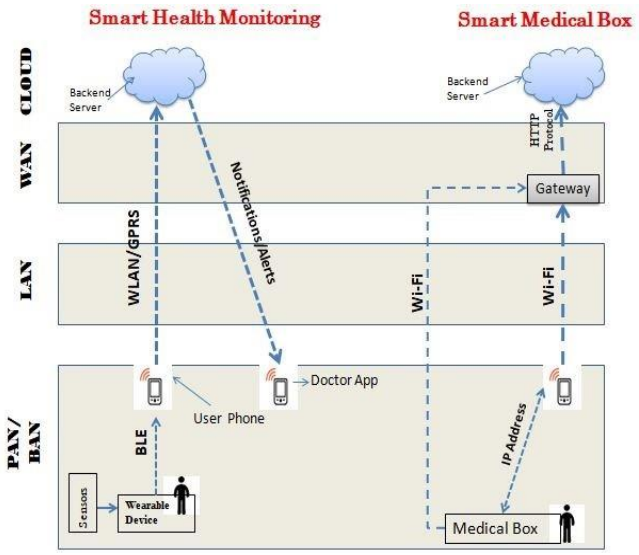

Fig. 6: Deployment Stages of Proposed System

5. Results

Tablets count which is obtained from the MediKit is downloaded in the form of excel sheet so that dose is maintained as shown in Fig 7.

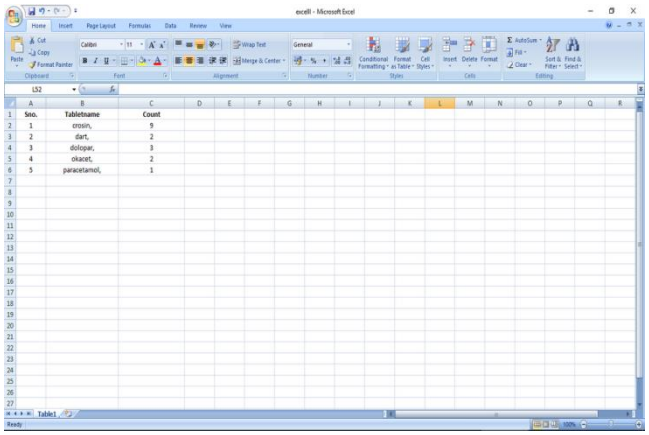

Fig. 7: Number of Tablets consumed

Scheduled medicine prescription sent from mobile application to MediKit is obtained on the web application is shown in Fig 8.

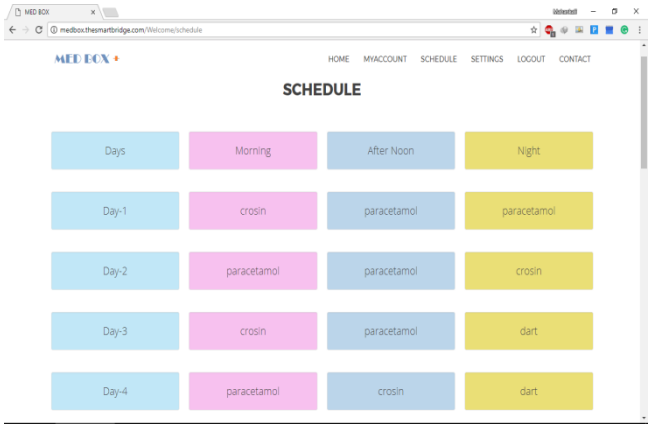

Fig. 8: Week schedule sent from mobile app

Tablets consumed by the patient are sent to cloud along with date so that this helps the doctor to verify whether patient has followed the dose. Fig 9

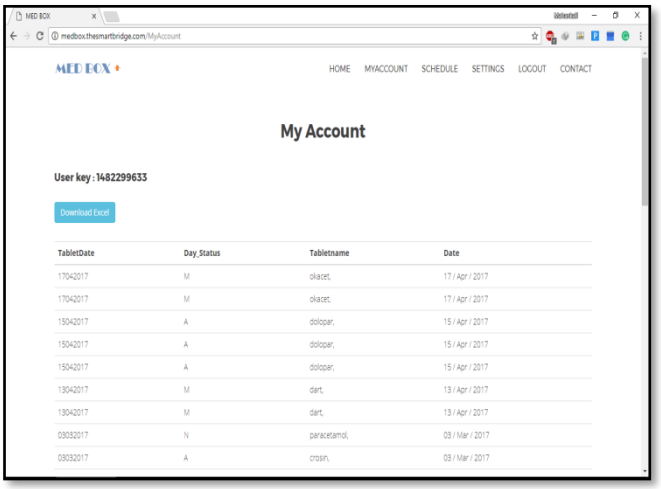

Fig. 9: Tablet details are uploaded to the cloud platform

The patient's vitals are monitored in the cloud and is visualized graphically as shown in Fig 10.

6. Advantages

a. Monitoring of health statistics Medicine, alarms and medication non-compliance control.
b. Emergency and medical management services.
c. Wireless identifiable Embedded healthcare systems.

7. Conclusion

Development of Wearable device which senses the vital parameters are monitored successfully and Integrating of Hardware modules Node MCU, Multiplexer, Buzzer, Push Button and Mobile Application to MediKit and every module has been placed carefully to give reasoned output, thus contributing to the best working of the unit. Secondly, using highly advanced hardware with the help of growing technology, the Smart MediKit showing significant without any deviation. Thus the MediKit has been successfully designed and tested.

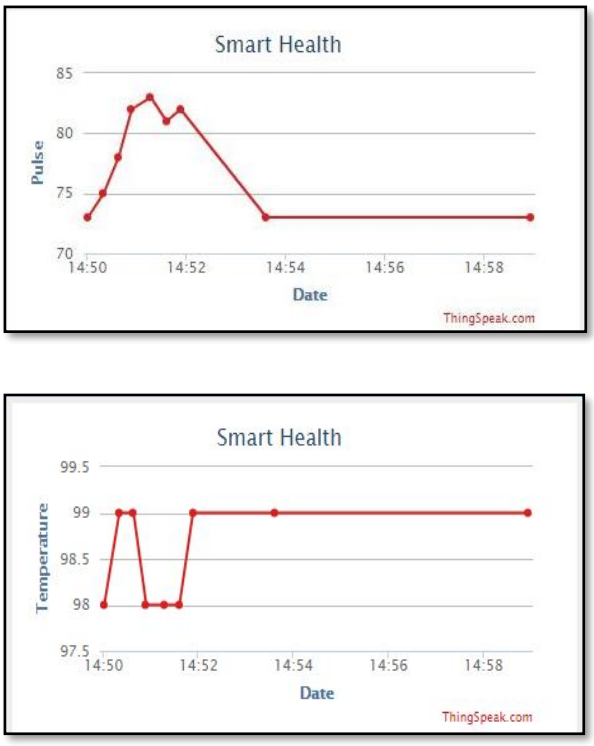

Fig. 10: Real time Monitoring of Data in cloud

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