International Journal of Future Generation Communication and Networking
Vol. 13, No. 2, (2020), pp. 265 -275

Smart Diabetes Monitoring Health Care System with the Support of IoT Environment

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Abstract

In recent years, the advancements in the Internet of Things (IoT) technology supporting connections of smart objects – things over the internet in a transparent way. Healthcare is one of the application domains in IoT along with sensors, processor aggregator and data storage platform as cloud computing by means of various communication technologies. The main goal of the proposed framework is to monitor the physical parameters such as Blood pressure, Respiratory level, ECG, oxygen level and Glucose level with the help of non – invasive sensors except glucose measurement for a Diabetes DCM patient. The proposed Smart Monitor System enhances healthcare delivery by communicating patient's data over three advanced network protocols – Bluetooth 5.0, Wi–Fi module and 4G LTE Mobile connectivity. The implementation of the system is achieved by the modified improved version of pine64 Microsystem and has facility to store the cloud database. If any abnormality, alert notification will be sent to the physician and caregivers / patients for emergency remotely. Based on this information, Doctors will prescribe the medicine to patient. In this framework; several characteristics have been examined to consider particular application such as data speed, power consumption, Data range, Bandwidth, Message capacity, cost and Battery life. In addition to this, the three challenges are scalability, compatibility and interoperability of the pine64 Microsystem achieved in a better way when compared with Arduino and Raspberry pi.

Keywords: *Arduino/Z-uno, Bluetooth module 5.0, IoT, Pine A64+2GB/LTS, Processor, Wireless Sensors, 4G LTE, Wi-fi /Z-wave*

I. INTRODUCTION

Health is always an important concern. However, the health of modern people is always interfered by various potential but dangerous factors, such as high blood pressure, and abnormal heart rate. In the process of designing a particular application, the health care architecture through IoT would be examined on the basis of characteristics of communication technologies and implementation of Hardware platform. With the help of additional Advanced Technologies, we can achieve data transmission in high speed, Increased data ranges, carry huge volume of data, better bandwidth, good Reliability and Security. By using the advanced hardware platform, we can make the system fast, cost effective with huge number of interfaces, easily extendable, compatible and achieve energy saving. Our proposed system will be a beneficial to Diabetes DCM patient for the diagnosis of healthcare parameters such as Blood pressure, Respiratory level, ECG, Oxygen level and Glucose without intervention of human. This system is designed to undermine the discomfort for the patients who cannot visit to doctors for daily check-up. IoT offers an encouraging technology to accomplish the aforementioned healthcare service. To achieve system efficiency

and patient safety – implement advanced communication mechanisms for the data transmission on an IoT server.

The Proposed framework is a wireless system, easy to handle, trustworthy and allows monitoring continuously from any time remotely. In case of any abnormalities, alert notification will

ISSN: 2233-7857 IJFGCN

be sent to both care providers and doctors to take necessary action for the immediate service near the patient.

II. LITERATURE WORK

R. Kumar et al [1] monitors patient's body temperature, respiration rate, heart rate and body movement using Raspberry Pi board and Internet of things. Raspberry Pi board is connected to the Internet, that board MAC address is registered to the Internet. After that in IoT website, add MAC address of this board. Then the sensors output is connected to the IoT website. Using this website like anybody can monitor patient's health status anywhere in the world. In this method, the putty software is installed to a computer using data cable to display output in that screen and connecting MAC address of the Raspberry Pi board to the internet via Ethernet, Wi–Fi or USB dongle.

Tatiana Huertas et al [2] In this paper, the project is made up of an android application along with eHealth systems and Bluno board. It helps to relieve congestion in hospitals and at the same time, to help people who (for different reasons) are not able to attend to a medical center. The e – HSSS (e – Health sensor shield) complete kit is used to study a different body signals which is referred as signal acquisition for this project. The BLUNO board is integrating Bluetooth 4.0 modem on an Arduino – UNO like board. The experiments were performed and showed different data for each sensor from 20 to 25 years old students. Shreyaasha Choudhary et al [3] examined the monitoring system with three architecture namely Wireless Body Server Network (WBSN), base station and GUI. They have presented the system with Microcontroller based IoT Platform via Wi-Fi module in cloud computing. They have measured patient's Data such as temperature, ECG and Heart beat using wearable sensors with corresponding IP address at the end user device. The GUI is used to store, analyze and sent the received data in SMS by FTP protocol to the physician through GSM modem. For the communication bandwidth, Wi-Fi and Web Server HTTP protocol is used.

Jorge Gomez et al [4] have monitored chronic diseases using ontology components with the software OWL and SWRL (semantic web Rule Language). The GPS has coordinated outdoor environment and works with BLE sensors. The apache Tomcat application is consumed in the web service. The patient data is displayed through visual interface on the screen of Android 4.4 based on patient readings. The alert notification has sent to the doctor and workout routines be done.

Omar s. Alwan et al [5] have presented the real – time monitoring system (RTMS) using efficient embedded system based wireless healthcare using ZigBee. This system has a capability to transmit the data between two embedded systems through two transceivers over a long range. The first part which contains Arduino with ZigBee will send the signals to the second device, which measure the patient data and send it to the first device through ZigBee transceiver. The designed system is demonstrated on volunteers to measure the body temperature which is clinically important to monitor and diagnose for fever in the patients.

K. Mohanraj et al [6] examined IOT based monitoring system on Raspberry Pi3 platform using LabVIEW software via RS232 communication. This developed system has measured patients data using biological sensors and analysed by communication port converter PI2303 (USB to UART) which is suitable for embedded applications. LabVIEW tool is most powerful for automation and measurement using GUI programming. The results obtained can be visualized on LabVIEW and far distance physicians can access it via internet.

SunilKumar Laxmanbhai Rohit et al [7] developed IOT based remote technology for medical treatment. The system is developed using ARM processor based Raspberry Pi. VNC server of Raspberry Pi OS connected to LAN. VNC viewer at the computer of doctor receives sensor values of patient. The energy consumption of data acquisition can be reduced with MEMS technology.

Prabal Verma et al [8] have discussed data transmission methodology to process the patient's real time data in FOG computing. They have also discussed temporal mining concept to analyse events adversity

ISSN: 2233-7857 IJFGCN

by calculating temporal health index of the patient at cloud layer. The BBN network based model was adapted in this system to achieve high accuracy and response time when compare with other algorithms.

Anirvin Sharma et al [9] have monitored health system in three layers: Detecting, Transport and Application. They have measured the body temperature and heart rate with specialized integrated clothing using textile based wearable system technology. The other vital parameters are linked externally to the providers. The current health condition is indicated in numeric value by calculating health index. The information's of various biosensors are detected and forwarded to the care provider using cloud based architecture via THINGSPEAK in transport layer. The data's are viewed from the application layer.

K. Narendra Swaroop et al [10] have considered the health monitoring system by communicating multiplexed data over three modes: BLE, GSM and WiFi (Internet) to ensure continuity in health monitoring. This system has developed on Raspberry Pi3 platform. The software architecture was deployed with MYSQL for the database, RESTful API for the services and IBEACON mobile application for the BLE (SR4.0 protocol). The CSR protocol 4.0 used to communicate multiplexed data through Bluetooth dongle with RPi3 for monitoring a patient's vital sign to a physician.

Vivek Pardeshi et al [11] have examined Health monitoring system using IoT and raspberry pi – A Review for detecting abnormalities in the health condition through GSM Technology via Internet. A Hardware model is developed and results are verified. The system is simple, Power efficient and easy to understand.

Kavita Jaiswal et al [12], has demonstrated that automates the problem of patient's vital data collection, delivery and processing with the help of edge Device (Raspberry Pi3 model B) and Docker Container. The system is experimentally performed how the warning notifications are generated through Raspberry Pi using digital Humidity and Temperature sensor. The python program in application software is coded in such a way that if the temperature and humidity value exceed the optimal value, then the message will be sent to medical staff via Gmail using MQTT protocol. The concept of Docker Container is used to run the app in an isolated environment.

III. PROPOSED SYSTEM

The conventional methods for DCM diagnosis lack the specificity and efficiency. It was thus difficult to obtain early and accurate diagnosis as well as treatment. Healthcare is one of the application domains in IoT along with sensors, gateway platform as processor aggregator and data storage platform as cloud computing by means of various communication technologies. This system would create an emergency notification for patients especially with serious illness.

The physiological parameters can be continuously monitored and displayed on the Smart Phones/ PC through internet. Our system will be beneficial to a Diabetes DCM patient. The proposed Smart Monitor System enhances healthcare delivery by communicating patient's data over three advanced network protocols – Bluetooth 5.0, Wi – Fi module and 4G LTE mobile connectivity.

System has another facility to store the cloud database and these database stores all information of patient's health parameters in structured format using MYSQL server supported by PHP programming Language. Based on this information, the physician will prescribe medicine to patient.

The sensor system is used to obtain the information or reading from the patient and the reading which read is converted into signals. These signals are provided for processing into the gateway platform, which is the IoT module. This information can be accessed by the doctors on his phone/computer and get the information. These data are collected through the IoT for real time

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patient. The patient data can be monitored accurately for which detection can be achieved successfully.

A. DEVELOPMENT OF SLAVE CIRCUIT WITH NEW WIRELESS COMMUNICATION TECHNOLOGY

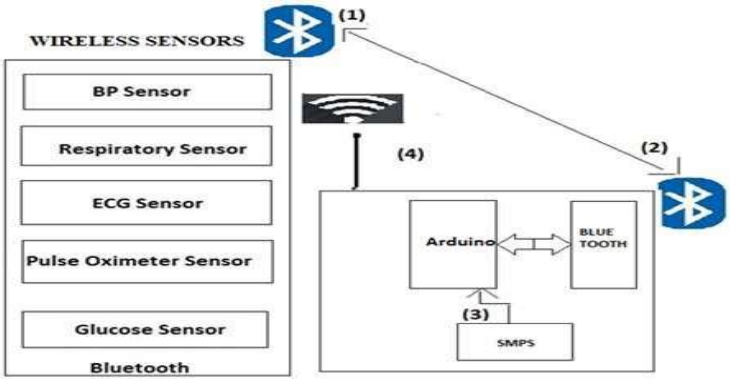

Fig.1 BLOCK DIAGRAM OF SLAVE CIRCUIT

The implementation of the system can be achieved by advanced Arduino Microcontroller and modified improved version of pine64 micro system. It is increasing patient safety and performance efficiency in the medical field. The aim of this prototype model is to demonstrate and implement a structure which includes slave and master circuit. The slave circuit integrates different sensors to monitor the patient's data and send it to Arduino via Bluetooth 5.0.

B. DEVELOPMENT OF MASTER CIRCUIT WITH VARIOUS COMMUNICATION PROTOCOL:

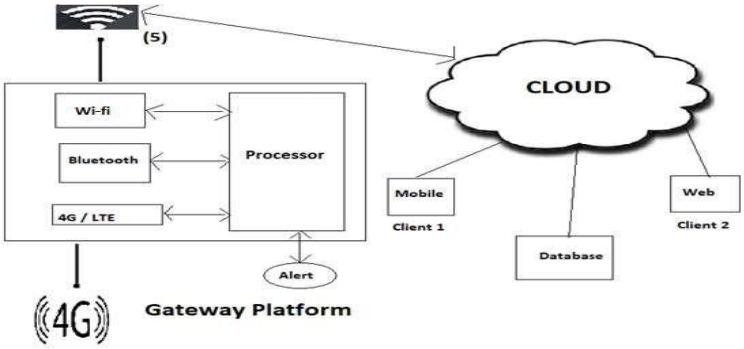

FIG. 2 : BLOCK DIAGRAM OF MASTER CIRCUIT

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The Master circuit has used processor as a gateway. This framework provides different protocols to support the communication and the collected data of patient are transmitted to the server for analyzing.

After analyzing, Doctors can provide timely treatment and then prescribe medicine when the patient health status is in abnormal condition. It is cost effective, resiliency, energy efficiency and achieved prolonging healthcare when compared with other monitor systems.

The implementation of activities are depicted in the form of flowchart in Fig.3

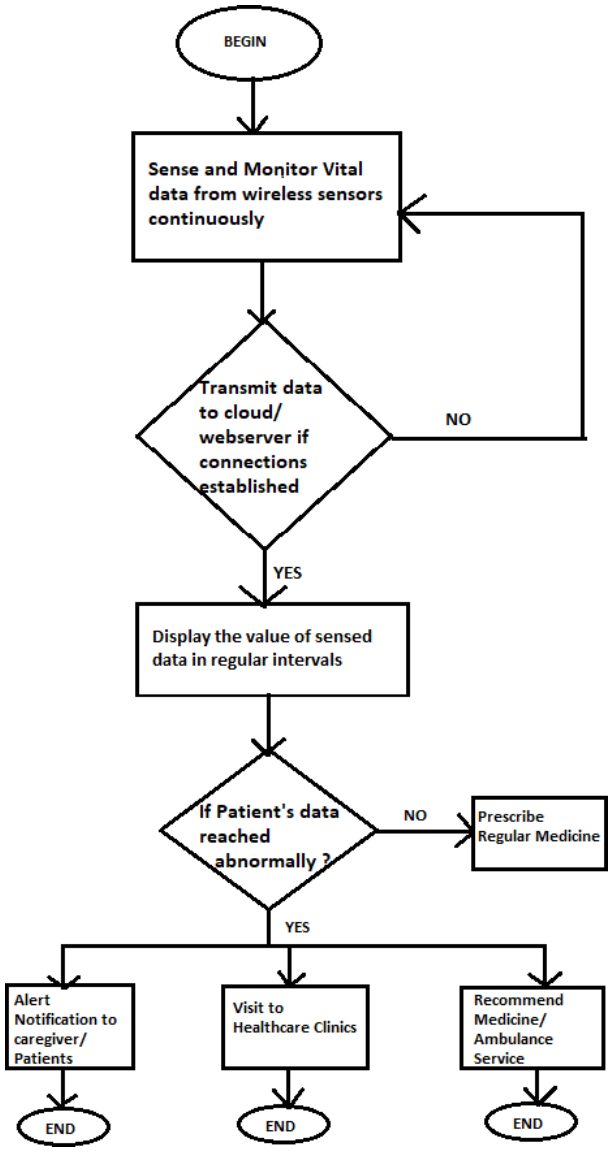

Fig. 3 FLOWCHART OF PROPOSED MODEL

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FUNCTIONS OF COMMUNICATION PROTOCOLS USED IN OUR PROPOSED MODEL:

Bluetooth 5.0 : Data in streamline has received in prescribed format.

Wi–fi : Data in streamline is pushed to Web server in cloud and displayed on web application.

4G / LTE : Broadband mobile networks provide reliability and high speed Internet Connectivity.

IV. COMPARATIVE STUDY OF EXISTING SYSTEM AND PROPOSED SYSTEM

S. No	WORK	COMMUNICATION PROTOCOL	HARDWARE PLATFORM	SENSORS USED	MONITORING SENSORS	MOBILITY	EXTERNAL DEVICE	USER INTERFACE
1	Kumar et al [1]	Wi-Fi via USB dongle or Ethernet (Short distance communication)	Raspberry Pi	Temperature Sensor, Heart Beat Sensor, Respiration Sensor, Accelerometer Sensor	Real time monitoring	Low	Laptop/ Computer	Web Portal
2	Tatiana Hauertas et al [2]	Bluetooth 4.0 (Short range communication)	BLUNO Board (Bluetooth 4.0 modem on an Arduino)	E – Health Sensor Shield	Continuous Monitoring	Low	Smart Phone	Android application
3	Omar S . Alwan et al [5]	ZigBee (Short range communication)	Raspberry Pi2 and Arduino Microcontroller	Temperature Sensor	Periodical Monitoring	Medium	LCD Monitor	Not Applicable
4	Kavita Jaiswal IIIT et al [12]	6 LowPAN (Medium Range Communication)	Raspberry Pi3 model B	BP Sensor, Temperature Sensor, ECG Sensor, Oxygen saturation level sensor	Constant Monitoring	Medium	Smart Phone, Server	Web application, Mobile application

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5	K. Narendra Swaroop et al [10]	BLE, GSM, Wi-Fi	Raspberry Pi3	BP Sensor, Temperature Sensor	Continuous Monitoring	Low	Smart Phone/ Tablet/ PCol Laptop	Web application, Mobile application
6	Proposed work	Advanced Bluetooth 5.0, Wi-Fi / 4G LTE – high speed Internet Connectivity	PINE A64 (+) – 2GB (offers LPDDR3 RAM) and Advanced Arduino Microcontroller	BP Sensor, Respiratory Sensor, ECG Sensor, Glucose Sensor, Pulse oximetry Sensor	Constant Monitoring	High	Smart Phone/ Web Server	Web application, Mobile application

V. DIFFERENT COMPONENTS OF A SYSTEM

1. HC-05 BLUETOOTH MODULE

HC-05 module is an easy to use Bluetooth SPP (Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration.
Operating frequency2.4GHz ISM band GFSK Modulation.

- Emission power is ≤4dBm
- 3.3 to 5V I/O
- UART Interface with programmable baud rate
- Speed for Asynchronous: 2.1Mbps / 160 kbps
- Synchronous: 1Mbps
- Range (4 times Increased)
- Large Message capacity
- Longer battery life
- Better Security
- High Reliability
- Good Compatibility

2. ARDUINO

It is the development board which uses C language to program. It is open Source Computer hardware.

Technical Specification:

- Microcontroller ATmega328

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- Input Voltage -7-12V
- Digital I/O Pins 14 (6 provide PWM output)
- Analog Input Pins 6
- SRAM 2 KB (ATmega328)
- EEPROM 1 KB (ATmega328)
- Clock Speed 16 MHz

3. PINE A64+ 2GB - LTS - 64-bit Single Board Computer - ARM Cortex A53 1.2 GHz Quad Core

PINE A64 - LTS is a modified improved version of PINE64 with long term support in terms of software and hardware. PINE A64+ is a powerful single board computer system with 2GB DDR RAM onboard. It has got ARM Cortex A53 based processor clocked at 1.2GHz making it ideal for stand-alone computer applications. It has got all the features to give a perfect multimedia computing performance. It can run Android, Ubuntu and several other OS as supported by designers of PINE64.

Features

- DDR3 Memory reduces 40% of power consumption
- Offers higher data rate
- Greater bandwidth
- Power efficiency
- Higher memory density
- Built in HDMI
- On board Management
- Huge number of interfaces
- Power and back up
- In built storage and Lithium battery

4. WIRELESS COMMUNICATION NETWORK

In this system, wireless communication network is required to be sent the measurements through a gateway platform towards cloud. The main network used here is IoT. Different wireless communication technologies can be used for (i) connecting the IoT device as local networks, and (ii) connecting these local networks (or individual IoT devices) to the Internet. The connectivity technologies are NFC, Bluetooth, zigbee, cellular network etc. In this paper, we use cellular network connectivity because of it has widespread mobile networks like 4G and LTE provide reliable high-speed connectivity to the Internet.

Specifications of 4G LTE Module:

- High speed GPS tracking
- High speed Data transferring
- Making remote controllable LTE Wi-fi Hotspot
- Large data downloads / uploads.
- Real time environmental monitoring
- Security and asset tracing
- Higher data transfer rate
- End to end Internet Protocol connection

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5. SENSORS

Respiratory Sensor

Respiratory monitoring prevents diabetes patients from many disorders which affecting the lungs such as asthma, infections like influenza, pneumonia and tuberculosis. The gas sensors are MQ series which uses an electro-chemical sensor with a small heater inside. They are highly sensitive for gasses and also used in room temperature. It can be calibrated with a known concentration of the measured gas. The generated analog output of the sensor can be readout by an Arduino analog input. Features: Very high sensitivity and quick response time. The output of the sensor is an analog resistance.

Pulse Oximeter

The monitoring based IoT application can be used to measure Blood oxygen saturation level which is referred as non – stop monitoring system. It prevents from problems like hypoxemia or hypoxia (low oxygen in blood) resulting severe damages to brain, lever and other organs.

It is useful in sensing oxygen level of blood as well as heart rate. It is a non-invasive method for patient oxygen saturation and the reading of peripheral oxygen saturation is not always equal to the reading of arterial oxygen saturation from blood arterial gas analysis, but the two are connected well for the non- invasive, convenient, safe, inexpensive pulse oximetry method is valued for measuring oxygen saturation in medical use. In its most common transmissive application mode, a sensor is placed on a patient's body on a very thin surface, usually an earlobe, or fingertip or a foot in-case of an infant. The two wavelengths of light passed by the sensor through the body part and the light is detected by the photo detector. The detector measures the wavelength by change in absorbance of the wavelengths and allows it to determine the absorbance due to the pulsating arterial blood alone, without skin, venous blood, fat, muscle, and bone.

ECG Sensor (AD8232)

ECG Monitoring measures the heart rate and the Electrical activity of the heart determines the rhythm of DCM patient. The recorded data helps to diagnose various problems like arrhythmias, myocardial ischemia and prolonged QT intervals. It is a fully integrated single-lead ECG front end with lower supply requirements up to 3.5V, 170 micro Amperes. It is an integrated signal conditioning block for ECG and other biopotential measurement applications. It is designed to extract, amplify, and filter small biopotential signals in the presence of noisy conditions, such as those created by motion or remote electrode placement. This design allows for an ultra-low ADC or an embedded microcontroller to acquire the output signal easily.

Glucose Sensor

Blood glucose monitoring prevents diabetic patient from the risk of insulin secretion and insulin action resulted due to metabolic disorder of multiple etiology. It is also supporting patients to prepare a chart for their meals, activities and medication times.

A tiny glucose-sensing device called a "sensor" is inserted just under the skin (subcutaneous tissue). It's very similar to insertion of an insulin pump catheter. Sensors are typically inserted in the abdominal or upper buttock area, and tape is used to hold them in place. The sensor measures the level of glucose in the interstitial fluid (fluid surrounding).

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Blood Pressure sensor

The monitoring of Blood Pressure data prevents a patient from circulatory systems problems. Blood pressure is the pressure of the blood in the arteries as it is pumped around the body by the heart. When your heart beats, it contracts and pushes blood through the arteries to the rest of your body. This force creates pressure on the arteries. Blood pressure is recorded as two numbers the systolic pressure (as the heart beats) over the diastolic pressure (as the heart relaxes between beats). The unit which measures this is called Sphygmomanometer.

Monitoring blood pressure at home is important for many people, especially if you have high blood pressure. Blood pressure does not stay the same all the time. It changes to meet your body's needs. It is affected by various factors including body position, breathing or emotional state, exercise and sleep. It is best to measure blood pressure when you are relaxed and sitting or lying down.

High blood pressure (hypertension) can lead to serious problems like heart attack, stroke or kidney disease. High blood pressure usually does not have any symptoms, so you need to have your blood pressure checked regularly every 10 seconds and changes it into an electrical signal.

VI Applications

1. Self-care services
2. Emergency Ambulance Services
3. Portable wireless system for home healthcare services
4. Clinics

VII Conclusion and Future Work

The Proposed architecture is cost effective, scalable, and compatible and supports Interoperability. The primary objective of the smart monitoring system is to allow the Diabetes DCM patient to receive continuous and seamless healthcare service to reduce frequent visit to the clinics and minimize their long stay in expensive healthcare centers.

In this framework, several characteristics have been examined to consider particular application such as data speed, power consumption, Data range, Bandwidth, Message capacity, cost and Battery life. In addition to this, the three challenges are scalability, compatibility and interoperability of the pine64 micro system achieved in a better way when compared with Arduino and Raspberry pi. In future, more research is required to present a functional prototype framework using Z wave to ensure security and privacy of data, low latency, resiliency and energy efficiency.

ISSN: 2233-7857 IJFGCN

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ISSN: 2233-7857 IJFGCN