IP Based Health Care Monitoring System   Using Particle Photon

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Abstract: IOT based healthcare monitoring systems are gaining more popularity nowadays. The main reason behind this is remote health monitoring. Remote health monitoring helps doctor to access real-time health data from sensor. By analyzing trend of health data, doctor can decide the harmfulness of the disease and prescribe medication. Remote health monitoring reduces frequent consulting visits to doctor. In this paper author represents particle photon based health care monitoring system. The Particle photon has built in Broadcom BCM43362 Wi-Fi   module and STM32F205RGY6 ARM cortex M3 processor. The whole System consists of SPO2 sensor, accelerometer sensor, and temperature sensor. The ARM processor has high processing speed 120MHZ with large memory and Broadcom43362 WIFI module provides WIFI protected access WPA™- and WPA2™ for powerful data encryption and authentication. These two features make whole system very powerful and efficient. Processor converts analog sensor data into digital form. This digitized sensor data transmitted via WIFI and stored in cloud. Using login ID and password, web server is accessed for visualizing person's health data. The system is compact, low cost and requires low power and useful for monitoring health status of old age patient, sport person as well as for healthy person.

Index Terms : **MQTT, IOT,PPG, Particle Photon, WIFI**

I.　　INTRODUCTION

Modernization and technical advancement improves standard of living of people, but it also creates health related issues. People are suffering from sleep disorders, stress related problems, heart attacks, diabetes, cancer like diseases in early young age**.**

In Today's worlds health care is not only important for old age person but also for any healthy person. Due to unavailability   of advanced equipments and lack of health awareness, people are suffering from heart related problem [1].

Along with heart rate, spo2, temperature and fall detection are also the vital parameters that should be measured carefully.

Heart rate is number of contractions of heart per minute and is varies with age and persons fitness [1].

Pulse oximeter sensor is non-invasive sensor that measures continuously, oxygen saturation of hemoglobin in the blood and heart rate[1][3]. It works on principal of photo-plexomography(PPG) which involves scattering and absorption of lights by   Infra-Red and Red LEDs. Oxygenated hemoglobin absorbs more Infra Red light and reflects Red light where as deoxygenated hemoglobin absorbs more Red lights and reflects Infrared light. A volumetric change in blood at finger tip is synchronous with heart rate giving real time heart rate values. Low level of spo2 means low level of oxygen saturation in blood, which leads to fatigue, headache, numbness, nausea.

Fall is one of major element that leads to injuries in old age people. It occurs due to osteoporosis, dementia and delirium. Fall in old age restricts day to day activities also degrades health. The severity of fall depends on location, age, early hospitalization of person. 30% falls results in injury and fall occurs frequently at care center, home, hospital [4]

The sensor ADXL345 is 3 axis accelerometer sensors that measures acceleration in 3 coordinates resulting from shock and static acceleration such as gravity. It is basically meant for fall detection in old person. In the given system buzzer connected to sensor give emergency alert to caretaker who can do hospitalization in case injury is severe.

This paper describes Particle photon based Health care system. Particle photon is open source IOT platform which has built in Broadcom 43362 WIFI module and 32 -bit STM32F205ARM Cortex M3 processor. High processing speed of 120MHZ and large flash memory of 1MB and 128KB RAM improves system efficiency. The system is better than Arduino based healthcare system as it has powerful processing capability, large memory and inbuilt WIFI. It also has more number of communication interfaces such as DAC, ADC, USB, I2C, I2S, SPI, UASRT, UART and CAN. The JTAG, SWD interfaces facilitates hardware debugging. For device communication, System uses Message Queue, Telemetry Transport (MQTT) protocol supported by Adafruit IO. Using a MQTT library or client, user can publish as well as subscribe to a feed to send and receive feed data. MQTT is better than HTTP as it reduces overheads, and provides higher efficiency needed for IOT communication.

Particle photon based system measures heart rate, blood oxygen saturation, and temperature and fall detection from sensors. On MQTT Adafruit IO web server, using login ID and Password it is possible to observe persons health data on dashboard.

II.   Proposed System Design and Implementation

The system is designed to monitor continuously and remotely health status of the person .The proposed system is based on Particle photon. Particle photon is a scalable, reliable, and secure Internet of Things device platform. The model consists of particle photon, temperature sensor DS18B20, Spo2 sensor Max 30100, accelerometer sensor ADXL345, HD44780 Liquid Crystal Display (16X2).

Sensor networks perform data acquisition from respective sensor. Analog sensed data is converted into digital form by Microcontroller and then transmitted via WIFI. The health data can be accessible to doctors by typing user login ID and password on Web server. In this system, web server provided by Adafruit industries and using these platform IOT devices interacts with MQTT protocol.
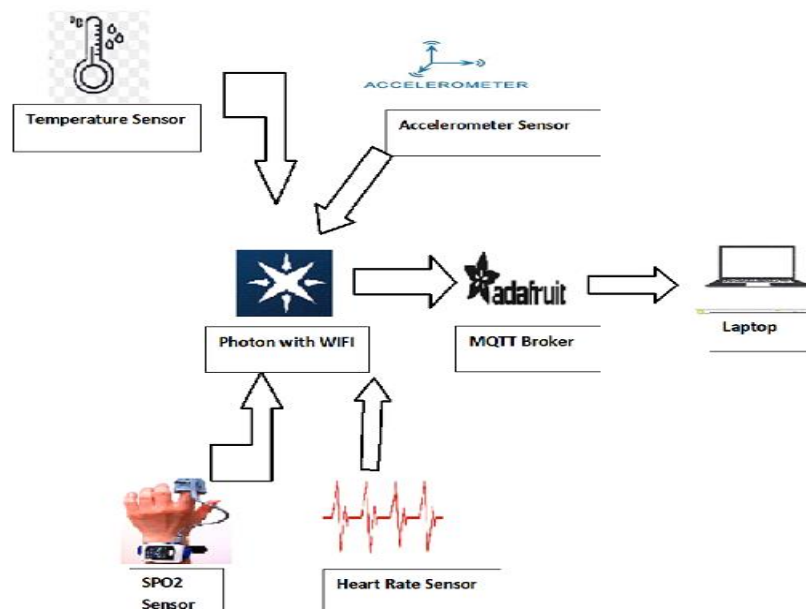

Fig2. Proposed system block Diagram

2.1 Hardware Description

2.1.1 Particle photon

Particle photon is a fully-integrated **IOT platform** built –in STM32F205RGY6 ARM cortex M3 32 bit processor with Broadcom BCM43362 Wi-Fi chip. Particle photon operates on regulated power supply voltage of 2.2VDC to 5.5VDC.It also includes a web-based IDE called particle build ,using that it is possible to develop and deploy code from anywhere .

Specifications of STM32F205RGY6 ARM cortex M3 processor are:

- It is 32 bit RISC processor with 3-stage pipeline structure
- Harvard Architecture
- 802.11b/g/n Wi-Fi
- CPU frequency- 120MHZ
- Flash memory/program memory- 1MB
- SRAM/Data RAM- 128 KB
- Supply voltage- 1.8 to 3.6v
- Backup RAM- 4KB.

Broadcom BCM 43362 WIFI ship provides high level of integration .It consist of 2.4GHZ Wireless LAN CMOS power amplifier that provides output power requirement for handheld devices.

Specifications of Broadcom 43362 WIFI are

- Single band 2.4 IEEE 802.11b/g/n.
- Integration of wireless LAN CMOS power amplifier with power detector and closed loop power control..
- It provides WIFI protected access WPA, WPA2 in order to support encryption and authentication.

2.1.2 Temperature Sensor DS18B20

The DS18B20 Digital Thermometer provides 9 to 12-bit (configurable) temperature readings in Celsius. Sensor can be used as one wire interface in which it communicates with microcontroller using single data line DQ. Power required for reading, writing and performing temperature conversion can be derived through this data line. For using temperature sensor in 1- wire mode, Parasite internal capacitor is CPP is essential. In Proposed system, sensor built with external power supply mode rather than 1-wire mode. The sensor system consists of 64-bit lasered ROM, temperature sensor, nonvolatile temperature alarm triggers TH and TL and a configuration register. The 64 bit ROM holds device unique address so multiple number of DS18B20 temperature sensors can be used in system. Configuration register sets resolution of sensor. The digitally converted temperature data is stored in 2-byte temperature register with sign extended two's complement form.

Specifications of DS18B20 temperature sensor are

- Unique 1-wire interface, one port pin for communication.
- Power supply range is 3.0V to 5.5V and resolution of 9 to 12 bit configurable.
- Measures temperatures from -55°C to +125°C.
   Fahrenheit equivalent range is -67°F to +257°F.

2.1.3 SPO2 sensor MAX 30100

Max30100 is pulse oximeter and heart rate sensor. It consists of IR and Red LED, photo detector with low noise analog processing circuit. Pulse oximeter measures the Oxygen saturation (SPO2) of hemoglobin in blood. In Reflective method of pulse

oximetry the two LEDs and the photo-detector are attached on the same side i.e. next to each other. These two LEDs transmit lights of different wavelengths. Red LED transmits wavelength of 650nm and IR LED of 950nm. Oxygenated hemoglobin absorbs more infrared light and allows more red lights to pass through. Whereas deoxygenated hemoglobin absorbs more red lights and passes more IR light. The sensor works on principle of photoplethysmography .Fluctuations in blood volume at finger tip is varied accordingly with heart beat. For large volume of blood, more light absorbed at fingertip and less light reaches to photo detector. SPo2 sensor uses I2C communication with MCU using SDA SCL lines.

Specifications of Max30100 Sensor are

- Supply voltage range is 1.8V and 3.3V.
- Ultra low power operation saves battery life.
- Integrated ambient light cancellation circuit with 16 bit sigma delta ADC and filter circuitry.

2.1.4 Accelerometer sensor ADXL345

It is low powered, cheap MEMS sensor. It measures static acceleration like gravity and dynamic acceleration such as shock/impact. It measures acceleration in 3 axes namely, x, y, z. This sensor provides high resolution up to 13bit. Digital output obtained from sensor is in 2s complement form which is accessible using I2C interface. This Sensor is used for fall detection for old age person.

Specifications of Accelerometer ADXL345

- 3-axis acceleration measurement system with a selectable measurement range of ± 2 g, ± 4 g, ± 8 g, or ± 16 g.
- Free fall detection and activity/inactivity detection.
- Supply voltage range: 2.0 V to 3.6 V.
- Wide temperature range from $-40°C$ to $+85°C$.

2.2 Software description

2.2.1 Particle build (Particle IDE)

Particle Build is integrated development environment (IDE) used for developing code for user application. For this, user has to create Particle Build account with user ID and password. Using particle build user can verify, flash, modify and save the code. Particle Build supports to access most of firmware libraries. These firmware libraries connect the sensor network to photon and supports reusing of code multiple numbers of times. Furthermore Photon supports firmware library development as it is possible to create new libraries with extension .h, .cpp. Most of Arduino libraries are compatible with photon so functions like serial.begin(),serial.print(),pinMode() are used in program code. System programming is done in C++ language.

2.2.2 Adafruit IO

It is web server provided by Adafruit industries. Using server it's possible to communicate with IOT devices using HTTP or MQTT protocol. System uses MQTT protocol. MQTT is publish/subscribe protocol known as message queuing telemetry transport. To use MQTT API, it's necessary to connect Adafruit IO to MQTT client library. MQTT libraries Adafruit_MQTT_SPARK.h , Adafruit_MQTT.h are used in program code. MQTT API supports Quality of service (QOS) level 0 and QOS 1 only. The proposed system uses QOS level 0. Feed of adafruit IO holds inputs of topic from sensors and dashboard are used for visualizing sensor data.

III.   Algorithm with flow chart

3.1 Algorithm

- Turn on power supply and initialize whole system.
- Set valid threshold values for sensor data.
- Acquire sensor data and compared with valid threshold values.
- Digitize valid sensor data using ARM processor and transmit using WIFI.
- Access and visualize sensor data using valid login ID and password over Adafruit IO server.

IV.   Result and analysis

The designed system is meant to measure temperature, heart rate, blood oxygen saturation and fall detection. Heart rate measured in term of beats per minutes. Normal heart rate range is from 60 to 100bpm. Heart rate values are varies accordingly with age and health condition of person.

Normal temperature normal range is 99.7-99.5 F.

DS18B20 is direct digital temperature sensor measures temperature in Celsius it then converted in Fahrenheit. For conversion header file math.h is added in program code. Reference values for pulse oximetry spo2in % and heart beat are set. Sensor real time values are compared with these values and values lesser than reference values are neglected.

Accelerometer sensor is set to sit and fall position along Z axis. The logic 1 state is stable sit state where as logic 0 is fall sate or emergency state for dashboard. In fall state condition buzzer attached to sensor sounds loudly for giving emergency alert to caretaker. So accelerometer sensor is useful for fall detection in old age person. Accelerometer and Spo2 sensor values are send on I2C protocol for communicating with ARM processor. Top level of MQTT is TCP client. MQTT libraries are added in program code. Measured values from respective sensors are pushed on particle cloud and observed on LCD display, Adafruit dashboard. Adafruit Io account access by login Id and password. User data is strictly protected as each user has unique AIO key.

Table1: Measured values on group of 5 people

Person with Age	SPO2 in %	Heart Beat(HB)in BPM	Temperature in Fahrenheit	Fall Detection along Z axis
Person1, age-7	95%	97	94.32 F	z=245,sit
Person2,age-28	95%	80	90.95F	Z=9,sit
Person3, age-35	96%	78	92.97 F	Z=241, Sit
Person4, age-70	96%	49	93.65F	Z=655,sit
Person5, age-66	94%	47	95	Z=96,fall

   For the sample of 5 people of different ages, real time values of SPO2, Heart rate, temperature and accelerometer are as above. It can be seen that depending upon age and physical condition the health parameters are get varied. Coresponding to real time measured sensor values on Adafruit dashboard LCD display and are as follows

Fig 4.1: Result on Adafruit Dashboard

Fig 4.2: Result on LCD

V.   Conclusion

The system measures accurately Spo2, heart rate, fall detection and temperature parameters.

The live health status of person can be observed by doctor, caretaker on Adafruit IO web server using login ID and password. So it is possible   for doctor to acquire and analyze health parameter from any remote place. After careful analysis he can prescribe medicine.
Photon is small size, low powered with inbuilt WIFI and microcontroller makes whole system compact and efficient.
Photon allows remote programming so program code can be modified from any far place.
The system is useful not only old age patient, but also helpful for healthy people, sport-person. For sport person the heart rate, temperature, spo2 values are useful in performance analysis and deciding training session.

VI.   Future Scope

The system can be modified by adding more sensors for measuring various other parameters like blood sugar; ECG Cholesterol etc.The system can be built using Arduino and LabVIEW graphical programming language. It best tool for data acquisition, data debugging, and data analysis.

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