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Open Source Real Time Internet of Things and Free RTOS Based Temperature Monitoring System

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ABSTRACT: The objective of this paper is to discuss an Internet of Things based system for consistent monitoring of sensors by means of low cost open source embedded system. The system is designed using an open source hardware platform (Arduino Uno) in which Free RTOS Application Programme Interface(API) is installed. Here, a temperature sensor is used as a monitoring device. The proposed system continuously monitors the sensor values and displays them on the Thing Speak cloud platform. A microcontroller unit combined with sensors and WiFi module (ESP-01) sends the measured values to Thing Speak(open source cloud platform). Free RTOS is an open source Real Time Operating System helps in implementing the multitasking feature where a number of sensors send data to the cloud and each sensing unit is considered as a task.

KEYWORDS: Open source system, Arduino Uno, WiFi Module, ESP-01, Sensors, Free RTOS, Internet of Things, Cloud

I. INTRODUCTION

Temperature monitoring for remote areas comes under a very critical task. Remote areas are those areas where the humans interaction is not possible. Nowadays due to the spread of serious infections like SARS, COVID 19 , Ebola etc. the job of healthcare professionals has become very difficult. In healthcare systems the patients health need to be monitored continuously. For the safety and security of both healthcare professionals and patients and to avoid the exposure time to collect the health related data, some sort of remote data transmission system is required that will collect the data of patients and transmit the data by the use of internet. In case of respiratory infections, fever or the rise in body temperature are very important parameters need to be analyzed a number of times by the healthcare experts. But this calls the direct exposure to the patient and the healthy person is at high risk to be infected. To solve this problem a remote temperature monitoring system need to be implemented that can transfer data remotely to the expert without getting exposed to the patient. It reduces the risk of exposure and lowers the transmission rate of the infection. This paper discusses the implementation of a microcontroller based remote health monitoring system using internet of things(IOT) as an effective solution for this issue.

The entire system implementation explores the use of open source software and hardware. It uses an open source computing platform for processing and controlling the system, Integrated Development Environment for writing program and getting machine executable file, a cloud platform used as data storage that can be accessed by anyone and anywhere, internet connectivity module for data transmission and using Free RTOS for the implementation of multitasking system where each sensing element is considered as a task.

Paper is organized as follows. Section II describes the review of literature for the proposed work. The design methodology is explained in Section III. The experimental setup and the experimental results are explained in Section IV. Finally, Section V presents conclusion and Section VI presents Future Scope.

II. RELATED WORK

The paper [1] explains the use of Internet of things for healthcare development. The paper monitors various health parameters like blood pressure, pulse, body temperature, heart rate using wireless sensor network. Internet of things is used for the processing, analysis and real time monitoring of data. The objective of this paper is to explore wearable health monitoring system. In the experimental setup, various data acquisition modules to measure heart rate, body temperature, pulse rate, blood pressure are used and data is acquired using wireless sensor network like zigbee, Wi-Fi, Bluetooth, ultra wideband, short range wireless transmission. After integrating the data the real time analysis and monitoring is performed using internet of things.

The paper [2] discusses about the role of internet of things for remote monitoring of weather parameters. It explains the use of various sensors to be connected to microcontroller and the acquired data is sent to server using Internet. The paper talks about the creation of smart environments using Internet of things. The weather parameters monitored in the paper are humidity, temperature, daylight. The data acquired is sent to twitter account so that the data is easily available. Ethernet connection is used here for uploading of data to internet. Other methods discussed for uploading the data is by using Google spreadsheets.

In paper [3], the authors discuss the role of internet of things for use in agriculture sector. The paper discusses the role of monitoring of temperature and humidity in agriculture for increasing the productivity. The experiment conducted in the paper uses the temperature and humidity sensor DHT11 that is interfaced to Raspberry Pi for the data collection. Python is used here for program development and the data is uploaded in the Internet of things cloud platform Thingspeak that uses Application Program Interface (API) that helps to upload the data on cloud and the uploaded data can be reviewed on the Thingspeak platform itself. The entire system is developed across an open source platform.

In paper [4] the author discusses about the design and implementation of smart patient monitoring system using Internet of things. The system is claimed to be a low cost system as compared to GSM based patient monitoring system where the data is sent via SMS. In the paper, the system uses smart sensors to monitor parameters like body temperature and pulse rate of patient along with the measurement of humidity and temperature of room where the patient is residing. The system basically explains about the use of wearable sensors that are connected to patients body and acquire the data continuously and record the data to RFID tag. The RFID tag then sends the data to Zigbee server by using zigbee protocols. The data is transmitted to therapeutic server using WLAN connectivity.

In paper [5] the author discusses the use of internet of things for environmental weather monitoring for the application in vertical farming. The paper uses GPRS based mobile network for the data transmission to internet for storage in cloud servers. The experimental setup consists of raspberry pi, node MCU, DHT sensor for temperature and humidity measurement, rain gauge module, BMP pressure sensor. The node MCU is a microcontroller unit where Wi-Fi module ESP8266 is present that can transmit the data via Wi-Fi to cloud.

III. METHODOLOGY

The sensors are used to measure physical variables and store the measured parameter values in cloud storage using internet so that the measured data is easily accessible to all. This increases transparency and easy sharing of data. The data is shared using internet hence the system is called as IOT based system.

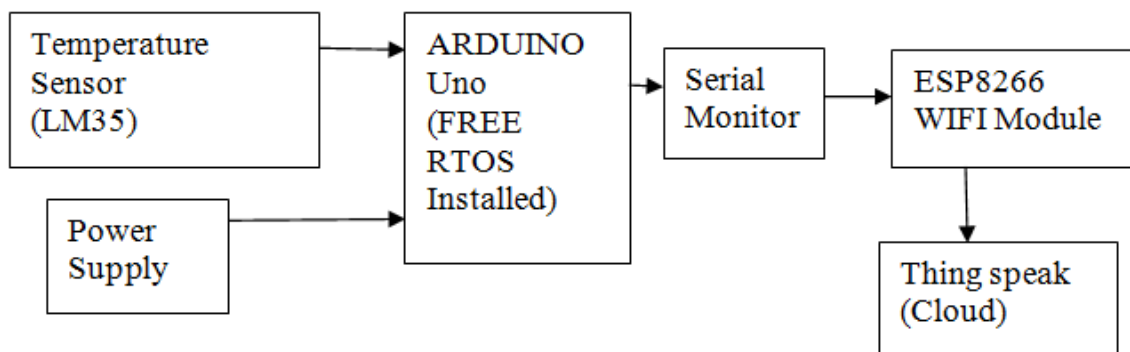


FIGURE 1: REMOTE MONITORING SYSTEM BLOCK DIAGRAM

As the sensed data is stored in a cloud, it can be accessed and analysed from any remote location using internet. We can combine this IOT based system with embedded systems to develop applications useful for control and monitoring applications with minimal human intervention. The main components of IOT based System are sensors, microcontroller, internet connectivity, WiFi module for connection establishment with internet and data transfer, cloud storage.

3.1 Body Temperature Sensor

Temperature of human body is an important health related data that requires continuous monitoring. For this calibration of temperature readings is must. Hence, LM35 is used as temperature sensor in the proposed system as it do not require any pre calibration.

3.2 Computing Platform

The heart of monitoring system is a microcontroller that performs the dual role of computation and control. Many microcontrollers are present like Atmega microcontrollers used in Arduino board that provides an open source platform for the monitoring purpose. The microcontroller job is to convert the sensed values or health parameters provided from the sensors to compatible values.

3.3 Wireless Communication System

Wireless Communication system is the essential part for IOT infrastructure. It acts as a bridge for dual direction communication for data collection. It can be applied to various IOT application. The wireless communication protocols in IOT is the set of rules used to exchange data between electronic devices. Bluetooth, Zigbee, Wi Fi are the most commonly used protocols and are open source.

3.4 Zigbee

Zigbee has an effective communication protocol for IOT networks. Zigbee is attributed with benefits for low power consumption, high scalability, strong security and durability. It employs destination-based routing making it a strong mesh network alongside being robust, resilient and flexible. The IEEE 802.15.4 standard is used by ZigBee.

3.5 Wireless Fidelity (WiFi)

Among all IOT communication protocols, wireless fidelity is the most popular for wireless local area network. It is based on IEEE 802.11 standard. It is a low-cost solution for indoor applications and home automation applications. It enables data security and installation process is easy.

3.6 Bluetooth Low energy

It is used for short range IOT communication up to 300feet. It is mostly used in smart lighting and smart connected IOT.

3.7 Narrowband Internet of Things (NB-IOT)

It is a low power wide area network radio technology developed for cellular devices. NB-IOT focus is on indoor coverage, low cost, low battery life, high connection density. IOT applications which require more frequent communications will be better served by NB-IOT.

IV. EXPERIMENTAL WORK

4.1 LM35 AS TEMPERATURE SENSOR

The temperature sensor used in the proposed work is LM35. The temperature sensor senses the temperature and provides the sensed data in voltage form. Hence, the output of LM35 is in analog form. The output represents the measured temperature in degree Celsius. The sensitivity of LM 35 is 10mV/degree Celsius. As the temperature increases, the output voltage also increases. For e.g. 250mV of output voltage from LM35 is equivalent to 25 degree Celsius. The sensor has three terminal and measures the surrounding temperature from -55 degree Celsius to 150 degree Celsius. The temperature output of LM35 is more precise than other sensors.[8]

4.2 Microcontroller Board

The microcontroller unit used in the proposed system is an open source platform-Arduino Uno. The microcontroller hardware and its Integrated Development Environment all are open source and distributive under a Creative Commons Attribution. The board is equipped with ATmega 328P microcontroller. The microcontroller board has 14 digital Input /

Output pins, 6 analog Input/ Output pins. The development of application software including from source code to executable code is performed using Arduino IDE. The board can be powered using 9Volt battery or by USB connection to laptop. The board is apt for communicating with computer, another microcontroller board etc. using serial communication input output port pins Rx and Tx. It has inbuilt UART TTL(5V) serial communication [9]

4.3 Wireless Communication Module (ESP8266)

The proposed system uses ESP-01 as Wi Fi module to connect the system to internet for data transfer. ESP-01 is developed by Ai-Thinker using core processor ESP 8266. The module is embedded with Tensilica L106 32bit MCU. The module objective is to have low power consumption. The 32bit MCU has a RISC architecture, CPU clock speed is 80MHZ and support for RTOS, Wi Fi MAC is provided. The module supports standard IEEE 802.11. ESP8266 is a System on chip with integrated microcontroller, memory, input output (GPIO pins), power supply. It is designed as high integration wireless System on Chip for space and power constraint mobile platform designers. It helps in building a standalone low-cost wireless connected system for IOT applications. In the proposed work, ESP-01 act as Wi Fi adapter, and can be connected to any microcontroller using I2C/UART interfacing. ESP8266 has inbuilt antenna switches, RF Balun, power amplifier, low noise receiver amplifier, filters, power management modules. It requires minimal external circuit [10].

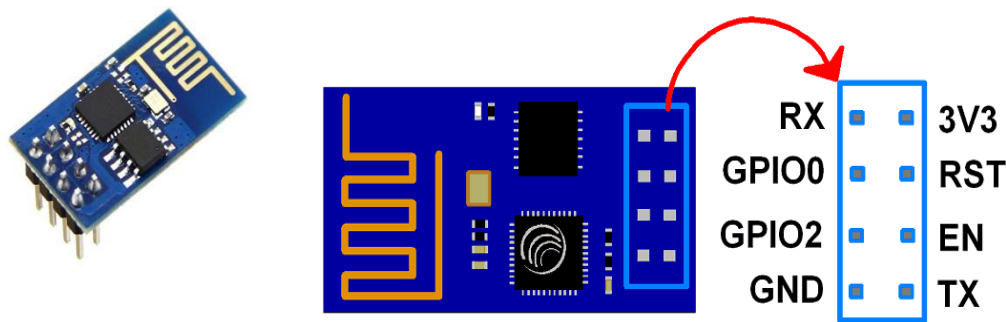


Figure 2: ESP8266 WiFi Module

4.4 ThingSpeak

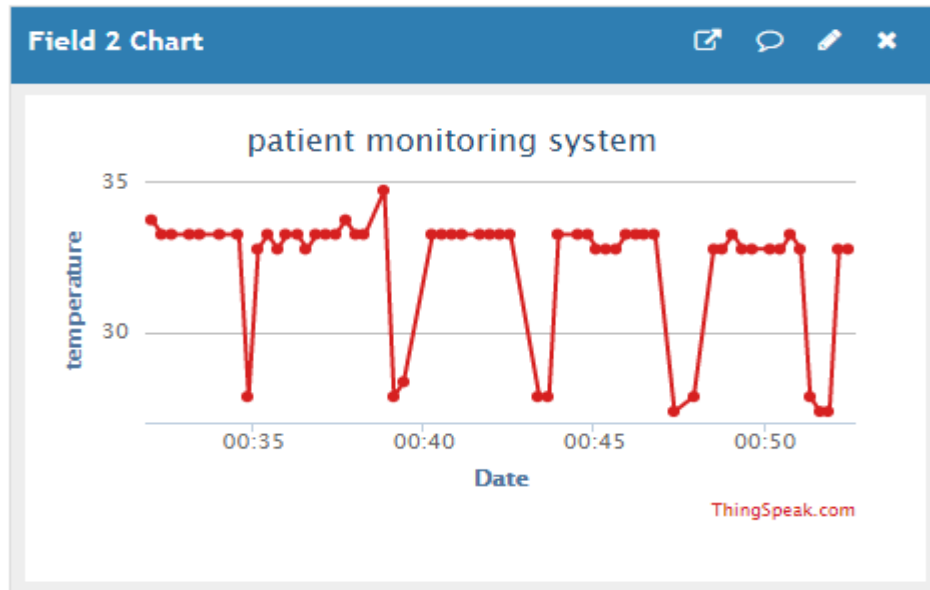
ThingSpeak is an open source cloud platform used to communicate with internet enabled devices. It works by the use of API key for accessing data stored on ThingSpeak cloud.

4.5 Free RTOS: Real Time Operating System

Free RTOS is an Real Time Operating System used easily with Arduino UNO by installing its libraries. Free RTOS uses pre-emptive scheduling algorithms where a high priority task pre-empts a low priority task. Free RTOS assigns priority to each task and schedule it to run. The RTOS uses Application Programme Interface(APIs) to facilitate multitasking in the system. The APIs commonly used is xTaskCreate() for creating a task. Task here means the sensors sensing the data. If the system has four sensors that are sensing four different types of data then RTOS recognizes these four sensors and their sensing operation as four task. The API vTaskStartScheduler() schedules the task in the program by assigning priority to them. Here , task priority '0' means lowest priority task and task priority values more than '0' is considered as high priority task. The API vTaskDelay() is used to set time deadlines for each task. In this system, a task is created as IDLE Task that is kernel level task and has high priority. The system is measuring the temperature data and sending the data to ThingSpeak cloud platform continuously. The kernel starts idleTask() and blocks the transmission of temperature data for some time interval. The idleTask() runs by the kernel till the task time is completed or the temperature monitoring task resumes again.

4.6 Experimental Results

The recorded temperature data at ThingSpeak platform using LM35 is displayed and found to be accurate. API keys are necessary to write the measured data to the Profile of Thing Speak. The Profile must be made public to view the data online. A snapshot of the Thingspeak profile where the data is collected and represented in real time in a graphical manner is provided below.



V. CONCLUSION

The paper implements a remote temperature monitoring system using internet of things and sensors. The proposed system successfully transfers the measured data to Thingspeak platform. The entire experimental setup uses open source platform. The microcontroller used is open source Arduino uno and its Integrated development IDE is also open source. The data is stored at Thing speak cloud platform that is an open source platform. The data measured through temperature sensor LM35 is successfully transferred to Thingspeak platform. Hence, a basic model for internet of things has been implemented through the proposed work.

VI. FUTURE SCOPE

The work may be extended to other computing platforms like Raspberry Pi module that uses ARM CPU for processing of data. The data can be transferred using other modules like Zigbee. More number of sensors can be connected to implement a high end data acquisition system.

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