Environmental Parameter Monitoring System Based on NodeMCU ESP8266, MQTT and Node-RED

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***Abstract*—The proliferation of Internet of things (IoT) in smart environmental monitoring has become more popular. It comprises of communication protocols like MQTT and end sensor nodes to be able to connect to the internet. The central units of this system prototype comprised of the ESP8266 NodeMCU microcontroller board interfaced with DHT 22 and Raspberry Pi which housed the MQTT broker. Environmental parameters of air temperature, air humidity, were selected to represent the state of the environment through sensing and the sensor data was visulized on Node-Red Dashboard.**

***Index Terms*—Environmental,ESP8266,NodeRED,Temperature, Humidity, MQTT**

I. Introduction

Due to the world's growing expansion of development in terms of technology globalization, what was considered a dream in last century is now a common reality through embedded system design and internet of things [1].

IoT is now widely used in almost every industry, and it is also a critical component of the proposed environmental monitoring system. The convergence of the IoT with cloud computing provides a fresh method for better managing data captured and delivered by low-power, low-cost microcontrollers [2].

Environmental parameters are essential for monitoring biological systems.Temperature and Humidity are the most important variables that have a great impact on various aspects of human needs and are required to be monitored constantly to draw insights and future predictions [3-4].These environmental variables are vital in areas of health,laboratories,food processing and productions just to mention a few [4].

II. Existing Literature

In [4] a design of Arduino based data logger which was miniature in size and collected sensor data was presented.The prototype stored variables of temperature and humidity in SD card and excel sheet which were offline modes.The Arduino based data logger was low-cost however they did not employ crosscutting technologies of Internet of things to send real time environmental sensor data to web dashboard.

In [5] the author proposed using an android platform to monitor the environment in real time. The designed prototype included an APP that made use of Internet of Things technology,a sensor network of ZigBee, a gateway protocol converter, a cloud server, and a mobile intelligent terminal. The web clients could refresh and retrieve temperature, humidity, and light intensity sensor data in realtime [5]. The demerits of the system were not limited to utilizing Zigbee modules which are costly to purchase and did not employ leading IoT protocols like MQTT.

Furthermore [6] presents an environmental monitoring system for the surrounding collecting humidity and temperature sensor data. The sensor data in the designed prototype is relayed through WI-FI to a thingspeak cloud platform were data visualization was implemented. The hardware interfacing in the prototype utilized Arduino Uno Microcontroller , DHT 11 temperature Sensor and ESP8266 Wi-Fi module [6]. The proposed system has some drawbacks as it relied on third party cloud platforms and did not utilize cross-cutting IoT protocols like MQTT.

In [7] the author discusses a monitoring system of the environmental conditions using wireless sensor networks which involved a hardware interfacing of raspberry pi, arduino and Zigbee Module. The sensor data realized was showed on graphical user interface through zigbee on the receiver end. The system had low power consumption but did not incorporate disruptive technology like MQTT.

Utilizing Message Queuing Telemetry Transport (MQTT) with Node-RED Dashboard, this paper shows how to build an ESP8266 NodeMCU Environmental Monitoring System. The proposed solution design makes use of a Raspberry Pi 3B+ with a MQTT mosquito broker and a DHT 22 temperature and humidity sensor connected to a NodeMCU ESP8266.

III. Aims and Objectives

The project's main aim was to design an Environmental monitoring System using NodeMCU ESP8266, MQTT and Node-Red. The specific objectives of the designed environmental monitoring system follow.

- To request sensor data of temperature and humidity from DHT22 sensor to NodeMCU ESP8266
- To publish temperature and humidity sensor data in the topics **esp/dht/temperature** and **esp/dht/humidity** respectively
- To retrieve the sensor readings to MQTT clients

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IV. System Overview

The system overview for the Environmental parameter monitor based on NodeMCU ESP8266, DHT 22, MQTT and Node-RED system is shown in figure 1.

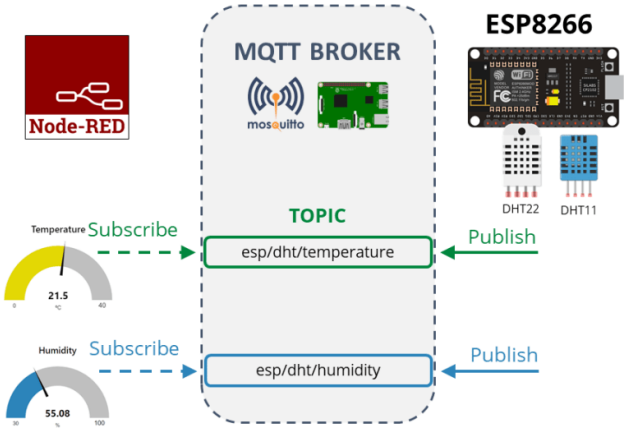

Fig. 1. Proposed System Overview [7]

V. Hardware Design

A. NodeMCU ESP8266

Espressif Systems' ESP8266 is a low-power, highly integrated Wi-Fi microcontroller [9]. The firmware is based on the Espressif System ESP8266 Wi-Fi SoC. It is low-cost Wi-Fi module with TCP/IP and a Tensilica Xtensa L106 Diamond series 32-bit RISC CPU and SRAM on-chip [9]. For data and program storage, the board features RAM of 128KB and Flash memory OF 4MB [10]. It offers a lot of computing power, therefore it's suitable for disruptive IoT applications.

B. Raspberry Pi 3B+

The Raspberry Pi (RPi) is a cost effective mini computer [12] It generates environments for a variety of programming languages, including Scratch, Python, and others. The frequency range of the Pi 3 model B+ is 700 MHz to 1.4 GHz. RAM memory is available in sizes ranging from 256 MB to 1 GB. The RPi 3B+ is powered by a 1.4 GHz quad-core 64-bit ARM cortex A53 CPU [12].The deployment of Node-RED flows and the MQTT mosquito broker are both run by the RPi 3B+ in this setup.

C. DHT 22

The DHT 22 is a relative humidity and temperature sensor with a digital signal [7]. The DHT 22's A-D converter chip transforms analog to digital and generates a digital signal containing data from temperature and humidity sensors. The DHT 22 sensor is equipped with an NTC thermistor that detects temperature and is connected to an 8-bit microprocessor that outputs temperature and humidity measurements as serial data. As a result, any microcontroller, including the NodeMCU ESP8266, may easily communicate with this sensor.

VI. System Software

A. Arduino IDE

Arduino IDE is an open source software used to write and upload sketches to Arduino compatible boards.It is cross-platform as it runs on mutiple operating systems [12]. The Arduino IDE is being utilized to upload sketches in the prototype and also to retrieve industrial temperature sensor data through serial monitor.

B. Mosquito MQTT Broker

MQTT stands for Message Queuing Telemetry Transport, and it was created for devices with limited resources and low bandwidth [14]. MQTT is a lightweight, open, straightforward, and easy-to-implement client-server publishing/subscription messaging transport protocol [14]. These characteristics make it suitable for use in the Internet of Things (IoT), where network bandwidth is mostly limited.

C. Node-RED

Node-RED is an open source JavaScript-based development environment based on Node.js that was created by IBM developers for the creation of IoT systems[15]. It's a virtual programming environment built on processes that connects hardware and software to build "data streams" from the sensor to the cloud [16]. The Node-RED dashboard depicts the system's user interface, which includes gauges that display data from environmental sensors.

VII. Description of Technology

A. Schematic Diagram of the Circuit

The diagram of the circuit outlines the overview hardware interfacing the DHT 22 with the microcontroller NodeMCU ESP866. The data pin of the DHT22 is connected to GPIO 14(D5) of the NodeMCU ESP8266 in this circuit diagram. The DHT22's VCC and GND are linked to the supply voltage and GND of the NodeMCU ESP8266, respectively. The Arduino IDE is used to upload the program code to the NodeMCU ESP8266 microcontroller.

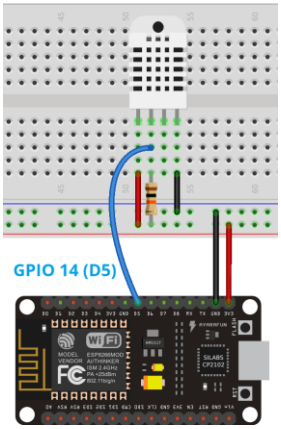

Fig. 2. Circuit Schematic Diagram [6]

B. Node-Red Flows

Node-RED flows wiring is displayed in Figure 3. which enables the Node-RED dashboard visualization of environmental parameter sensor data which is published in clients web dashboard.

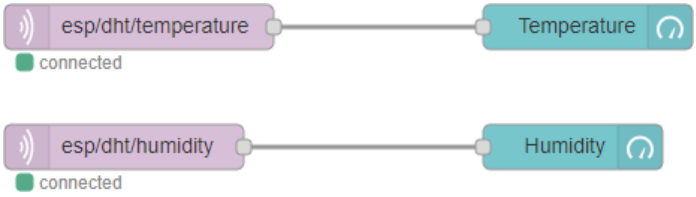

Fig. 3. Node-Red Flows

VIII. Results and Analysis

A. Implementation of Systems Prototype

Figure 4 displays a prototype of environmental monitoring using MQTT and Node-RED, in which a DHT22 temperature sensor is connected to a NodeMCU ESP8266 to publish sensor data to a mosquito MQTT broker.

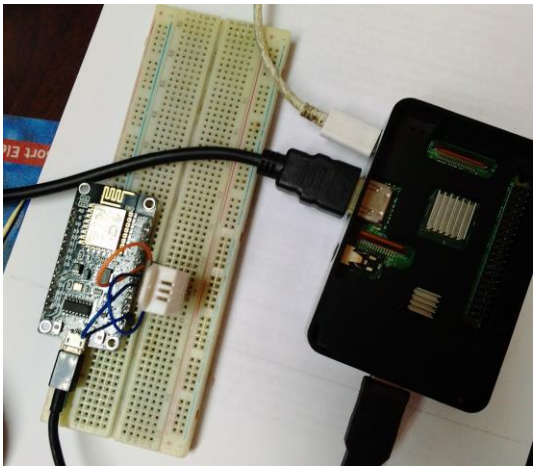

Fig. 4. Implemented Prototype

B. Serial Monitor Results

Figure 5 display's sensor data from the NodeMCU ESP8266 sensor node on a serial monitor COM port 6 at (115200) baud rate with the IP address(192.168.8.101) linked and the notice of connection to the mosquito MQTT broker.The messages which the ESP8266 publishes and receives are displayed, revealing the environmental parameter monitor's real-time events using NodeMCU ESP8266, MQTT, and Node-Red with reduced latency and premium bandwidth.

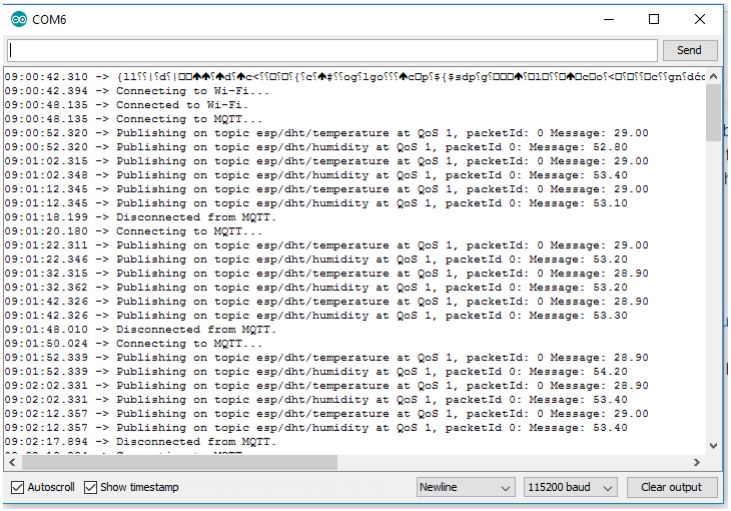

Fig. 5. Results on Serial Monitor

C. Web Dashboard on Node-RED

The humidity and temperature sensor data readings from the NodeMCU ESP8266 are published every 10 seconds on the **esp/dht/temperature** and **esp/dht/humidity** topics, respectively. The Node-RED dashboard, which supports MQTT clients, is used to retrieve this temperature sensor data if it subscribes to the following topics. Figure 6 depicts the Node-RED web dashboard, which displays sensor data for environmental parameters as a gauge.

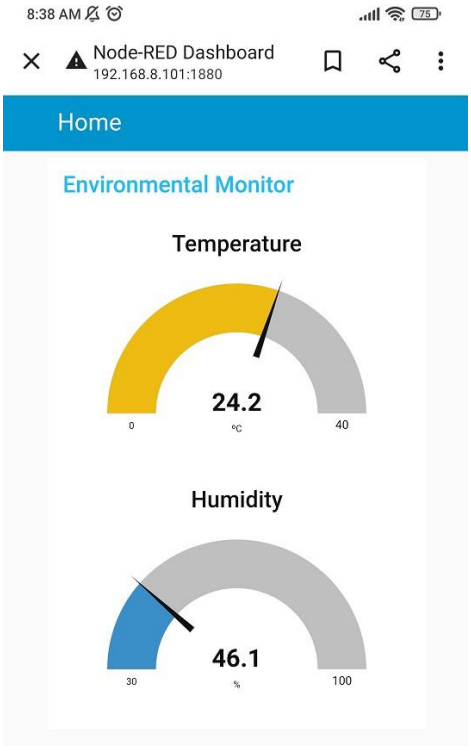

Fig. 6. Environmental Sensor Data

IX. Conclusion and Future Work

The design and implementation of a newline environmental parameter monitor solution based on the ESP8266, DHT 22, MQTT mosquito broker, and Node-RED is described in this work. The NodeMCU ESP8266 interfaced with the DHT 22 publishes temperature and humidity sensor data from the DHT 22 through MQTT and displays it on a Node-RED dashboard for MQTT clients.

The mosquito MQTT broker and Node-RED software running on a Raspberry Pi 3B+ enable communication between the NodeMCU ESP8266 and the Node-RED application in the developed prototype.

Interfacing numerous environmental sensors to gather sensor data for other parameters, deploying more sensor nodes and aggregating the sensor data, and powering the sensing node with renewable energy will be among the future works of the environmental monitor presented.

Acknowledgment

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