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Design and implementation of GPS controlled environment monitoring system based on internet of things

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Abstract
These days, one of the major uses of wireless sensor networks is environment monitoring. The main factors causing the changes in the environment are radiation, water pollution, and air quality pollution. Sufficient oversight is required to ensure that a healthy society and sustainable global growth are maintained. Environmental monitoring has evolved into a smart environment monitoring (SEM) system in recent years due to developments in the Internet of Things (IoT) and contemporary sensor technology. The authors suggested a system that is made and put into place to track environmental variables including temperature, humidity, air quality, and concentrations of hazardous gases in order to combat this pollution. This gadget will transmit sensor data to Firebase, a real-time cloud database for data storage and sharing. Firebase will provide data to Android applications, which can then visualize it. Because it offers real-time positioning data, users may precisely ascertain their location, follow their progress, and navigate to their intended destinations.

Keywords: Design, GPS, environment, monitor, IoT

Introduction
Research Background
The term "Internet of Things" (IoT) describes how many of the things that are all around us-any hardware that has Bluetooth, Wi-Fi, or other modules that let it connect to the internet-are connected to networks in one way or another. It's also possible that the Internet of Things (IoT) is a flawless fusion of the physical and digital realms, facilitated by networked sensors, actuators, embedded hardware, automobiles, appliances, and software, which will fundamentally alter how we interact, live, and work [1].
One of the wireless sensor network's applications is environmental monitoring. The main factors causing the changes in the environment are radiation, water pollution, and air quality pollution. Sufficient oversight is required to ensure that a healthy society and sustainable global growth are maintained. Environmental monitoring has evolved into a smart environment monitoring (SEM) system in recent years due to developments in the Internet of Things (IoT) and contemporary sensor technology. This study discusses SEM contributions and research projects that monitor radiation contamination, water quality, air quality, and agricultural systems.
The authors suggested developing and putting into practice a system to keep an eye on environmental factors including humidity, temperature, air quality, and concentrations of hazardous gases. This gadget will transmit sensor data to Firebase, a real-time cloud database for data storage and sharing. Firebase will provide data to Android applications, which can then visualize it. The Neo M8M GPS module is a high accuracy GPS navigation and positioning module that is a concurrent GNSS module for the U-Blox M8. Because it offers real-time positioning data, users may precisely ascertain their location, follow their progress, and navigate to their intended destinations. Thermistor and capacitive humidity sensor are the two methods used by the DHT22 temperature and humidity sensor to monitor temperature and humidity, respectively. The MQ2 Gas Sensor is a smoke-sensitive device that can identify combustible gases and a variety of gases with quantities of gas everywhere. The MQ7 sensor measures the amount of carbon dioxide (CO_2) in the air and is a carbon monoxide (CO) gas detector. The MQ 135 sensor can identify hazardous or poisonous gases present in the atmosphere.

All of the system's instrumentation and parameters, including the temperature, humidity, air quality, and hazardous gas sensors, will be managed by the ESP 32. The ESP 32 microcontroller board and the I2c LCD display together provide real-time data from all sensors as well as GPS latitude and longitude readings.

Objective

The main focus of this research is-

- To design a real time temperature, humidity, air quality and harmful gas monitoring system without any human interaction.

Literature Review

The literature review is summarized in the next part, along with previous research that supports our findings. In the current setup, four sensors-the DHT22 and the gas sensor (MQ02, MQ07, and MQ135)-are in communication with the GPS-controlled environment monitoring system via the Node MCU ESP 32. The Node MCU collects sensor data from specific places and uploads it to the Internet of Things platform so that users may start examining it right away. The gadget is a component of the Internet of Things since it requires network access using a GPS module (Neo 08) connected to a Node MCU ESP 32 microcontroller board. It requires less human interaction on that part of the system by integrating data and ambient factors through sensors.

Many research works are being proposed in this area-

Saima Zafar, Ghosia Mira, Rajaa Baloch and Danish Murtaza, Khadija Arshad (2018) [2], has proposed "An IoT Based Real-Time Environmental Monitoring System Using Arduino and Cloud Service". The method for monitoring the temperature and humidity of the surrounding environment in real time is presented in this study. Wi-Fi is used to transmit the detected data to the cloud, where graphical analysis and real-time data are shown. For the end user, an Android application is created so they may use their smartphone to monitor the surroundings of the location where the hardware is installed. This system may be expanded to create a home automation system, in which the humidity and temperature readings that are tracked can be utilised to initiate a response and manage the heating and cooling equipment using a mobile app. Examining this system is essential to comprehending the creation and use of IoT applications, and it forms the basis for several helpful advancements in this area.

Neel P. Shah and Priyong P. Bhatt (2017) [3] has proposed "Greenhouse Automation and Monitoring System and Design and Implementation". This essay explains how the current state of climate change and its effects on the environment have spurred farmers to build greenhouses on their properties. However, maintaining a greenhouse and its planting requires a lot of effort, and most of them carry out essential tasks instinctively. A lack of high-quality data, which is essential for crop improvement, is another issue facing agricultural experts. In light of this, we have created a highly efficient solution utilizing Internet of Things (IoT) technology to address these specific issues. Our system automates greenhouse maintenance procedures and closely monitors the growing conditions within the greenhouse.

Hamed M. Almalki (2020) [4] has proposed "Real-Time Industrial Environment Monitoring System Design". The goal of this study is to propose a new design form with improved capabilities for an industrial environment monitoring system that is affordable, dependable, efficient, and real-time, drawing on multidisciplinary achievements in several engineering domains. The proposed design aims to track, monitor, evaluate, and record the parameters and conditions of pollution sources in industrial manufacturing factories. This will guarantee an acceptable level of environmental quality in the factory, ensure the safety of workers, materials, and machinery, and ultimately lead to more optimized factory operations. Utilizing both custom built modules and widely accessible hardware, the system design is constructed. Real-time readings and continuous monitoring are conducted to assess the value and status of different environmental contamination sources and situations. All sensor modules wirelessly transmit the collected data to the main control unit, which processes it, computes the climate indices, and makes the necessary corrections.

Aparajita Das, *et al.* (2018) [5] has proposed "Design of an IoT based Real Time Environment Monitoring System using Legacy Sensors". This article covers the design of an operational prototype based on Internet of Things (IoT) principles for real-time environmental condition monitoring utilizing a few inexpensive, widely accessible sensors. An Arduino Uno microcontroller board uses a number of sensors to continually monitor, process, and manage the many environmental factors, including temperature, humidity, air pollution, sunshine intensity, and rain. Recorded information is disseminated through the internet using an ESP8266 wireless module. The proposed system permits data saving and transfers sensor data over the HTTP protocol to an API named Thing Speak. The suggested method functions effectively and is dependable. The prototype has been used to track and evaluate real-time data utilizing environmental graphical data.

Shao ling Li *et al.* (2011) [6] has proposed "Design and Implementation of Agricultural Greenhouse Environmental Monitoring System Based on Internet of Things". A number of issues, including hard and time-consuming ones, arise when certain information-such as temperature, humidity, wind, rainfall, and soil PH-is measured manually during agricultural production. This study describes the design of an agricultural greenhouse environmental monitoring system that leverages the Internet of Things to provide remote, real-time monitoring of greenhouse environmental data through the integration of wireless, mobile, and Internet networks. Using the ZigBee protocol, a wireless sensor network is set up to gather environmental data, such as temperature and humidity. Ultimately, the control center allows access to the gathered environmental data via the internet and mobile networks. The monitoring system is capable of real-time agricultural and environmental information monitoring as well as brief message warming. In the research under review, we developed an environment monitoring system for agricultural greenhouses by integrating wireless sensor networks, mobile networks, and the Internet. Its benefits over traditional wired networks include simple installation, inexpensive maintenance, and frequent updates. There are several potential uses for the system in precision agriculture.

Chirayu Pranav Darji (2021) [7], has proposed "IoT Based Sensor for Humidity and Temperature Measurement in Smart HVAC Systems". HVAC stands for heating, ventilation, and air conditioning at the beginning. They explain how an HVAC system works by using heating and cooling to regulate and keep an eye on a room's temperature. It also regulates the amount of humidity in that space by regulating the airflow and distribution inside the space. Expensive sensors are needed to measure the humidity and temperature. These sensors are additional services, such as data storage and cloud assistance. Thus, I'm putting up a proposal for an Internet of Things sensor that uses the ESP8266, Arduino-Uno development board, and Thing Talk cloud to store data in the cloud. This affordable sensor monitors and regulates the system's temperature and humidity by automatically monitoring and adjusting the humidity and temperature. It does this by sending the data to a secure server. After examining this project, the system is very dependable, strong, economical, and efficient.

After going over every study article, the suggested system realized that the projects were similar to this one, which is an environment monitoring system that takes necessary measurements of temperature, humidity, air quality, and hazardous gases. It's interesting to note that while some other researchers utilized an Arduino MCU ESP8266 in their work, the creator of this project used an ESP32 (MQ2, DHT22, Neo 08), which is more modern and more reasonably priced.

Methodology

This project's methodology chapter is crucial. Authors has employed a waterfall development methodology in the suggested system. The linear-sequential life cycle model was called the Waterfall Model. It is quite easy to use and comprehend. There is no phase overlap in a waterfall model; each step must be finished before the next can start. The software development process is shown in the waterfall model as a sequential, linear flow. Usually, in this Waterfall paradigm, the result of one phase serves as the sequential input for the following step.

The following illustration is a representation of the 5 phases of the Waterfall Methodology;

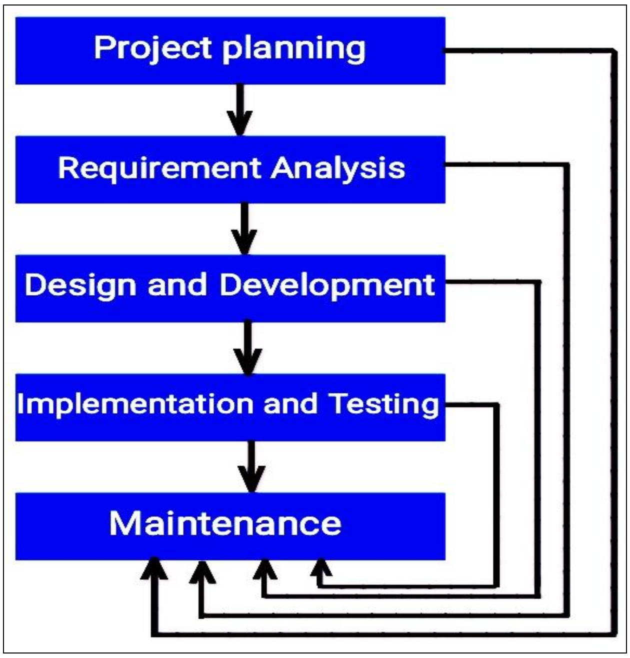

Fig 1: Waterfall Development Methodology Diagram for the proposed.

Description of Methodology

Project Planning

In project management, project planning is a procedural stage when necessary paperwork is generated to guarantee the project's effective completion. All steps necessary to create, prepare, integrate, and coordinate new plans are included in the documentation. The project plan outlines in detail how the work will be carried out, overseen, managed, and concluded. The writers have chosen the areas in which they will work during this phase.

The writers discovered several environmental issues in the city of Dhaka. The issue with the Environment Monitoring System is becoming worse every day. The writers talk about the issue with authorities controlling the GPS-controlled environment monitoring system. The writers made the wise decision to find a solution to the issue.

Requirement Analysis

Requirement analysis is the process of developing good specification for any hardware or software development of project. In this stage required hardware analysis was learned to build the project. Every work has some requirements according to needs. The proposed work does require some specific resources.

System Requirements-system requirement can be isolated into two types

1. Software requirement
2. Hardware requirement

Software Requirements

1. Arduino IDE
2. Firebase
3. Kodular
4. Easyeda
5. Language C

Hardware Requirements

1. ESP 32
2. Neo 08 GPS

3. DHT 22
4. Gas sensor (MQ2, MQ07 and MQ135)
5. Switch
6. 1602 Display with i2c
7. Buzzer
8. Battery 18650
9. Charger
10. Booster.

User Requirements: What the user expects from the system is one of the user requirements. The customer desires an easy-to-use, affordable, real-time data access system with accurate accuracy, as well as one that is straightforward and easy to monitor and control.

Design and Development
The process of specifying the parts, modules, interfaces, and data needed to build a system and meet certain specifications is called design. The process of developing a system, including its models, procedures, practices, and approaches, is called development.
The authors created a sensor-equipped device that allows users to monitor the GPS-controlled environment monitoring system via a mobile application. The application can alert users with real-time data from the environment monitoring system and its standing, and it also stores data in the cloud using Firebase. That information will be shown via an Android app.

Implementation and Testing
The act of carrying out the plan and bringing the project to fruition is known as the implementation phase. Debugging is the act of fixing the flaws discovered during the testing phase. Testing is the process of locating mistakes or defects in a software product and may be done manually by testers or can be automated.
Unit testing was utilized by the authors to confirm whether or not the gadget is operating flawlessly. One kind of White Box testing is unit testing. In reality, it's a software testing procedure. The suggested gadget has been put to the test in real time for temperature, humidity, air quality, and hazardous gas, and the findings show that it functions effectively.

Maintenance
After a product is delivered, maintenance is the process of making changes to address issues, enhance functionality, or improve other aspects of it. Many people believe that maintenance only entails correcting flaws. There are several problems with the GPS Controlled Environment Monitoring System Based on Internet of Things project that the authors have presented. Patches are published to address certain problems. Better versions of the product are also launched in an effort to improve it. The Internet of Things-based GPS Controlled Environment Monitoring System is maintained.

Design and Development
System Architecture
This is the proposed System Architecture

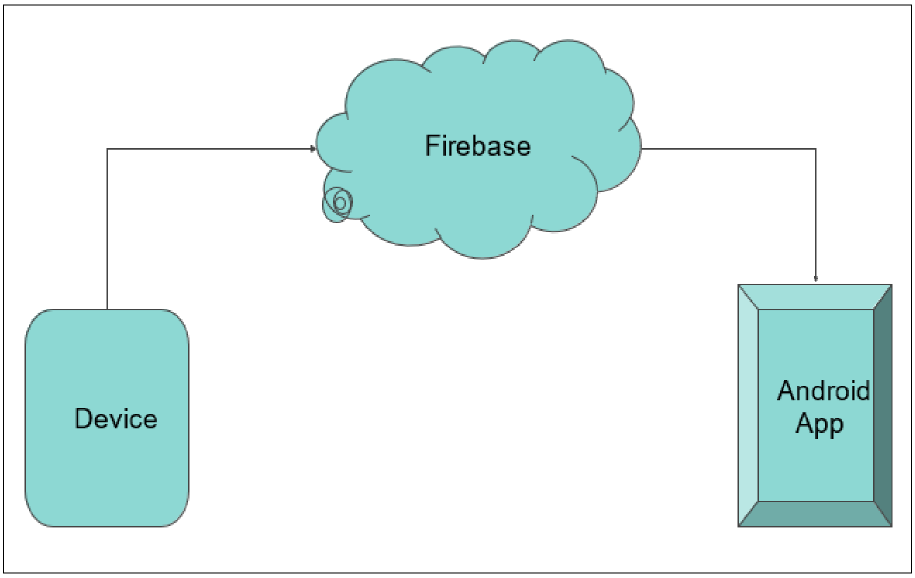

Fig 2: Proposed System Architecture.

Description of System Architecture
The device will broadcast sensor data to Firebase, where Firebase is a real-time cloud database to hold and share data. Android applications will get data from Firebase and visualize it.

Block Diagram

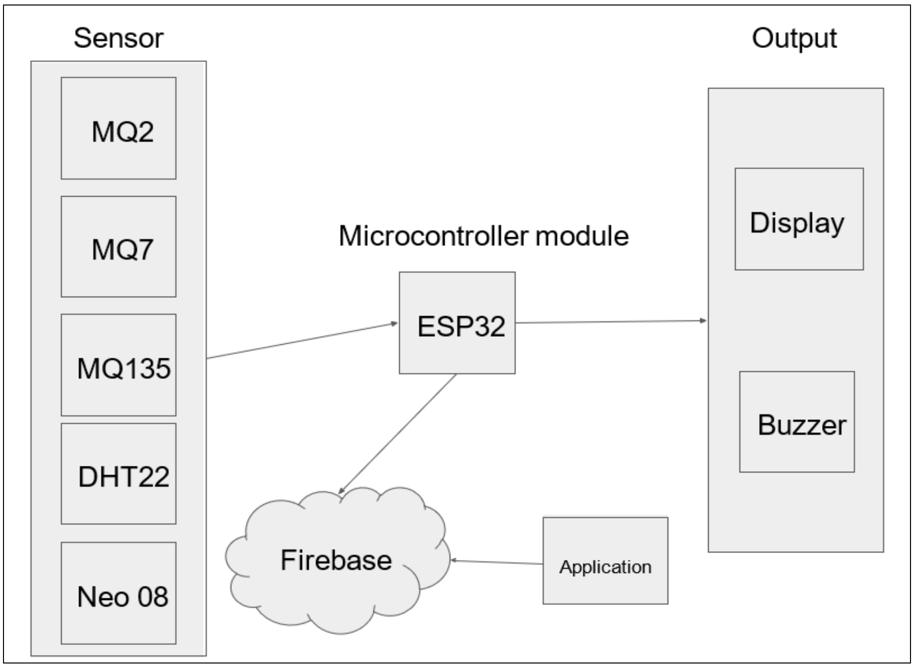

Fig 3: Block Diagram of Proposed System.

Description of Block Diagram

The ESP 32 microcontroller module is linked to every sensor in this system, including the MQ2, MQ7, MQ135, DHT22, and Neo 08 sensors. The hardware components were linked to the (ESP32) microcontroller module's outputs, which included a buzzer and display. You may use a router firebase to store data on a cloud server. The user may access the device's location, the ESP 32 (microcontroller module), and real-time data reading via the mobile application.

Flow Chart

An illustration of the steps, processes, or actions taken by individuals or objects in a complicated system or activity is called a flowchart. The author's suggested Design and Implementation of GPS-controlled Environment Monitoring systems based on Internet of Things algorithm is diagrammatically represented in the flowchart that follows.

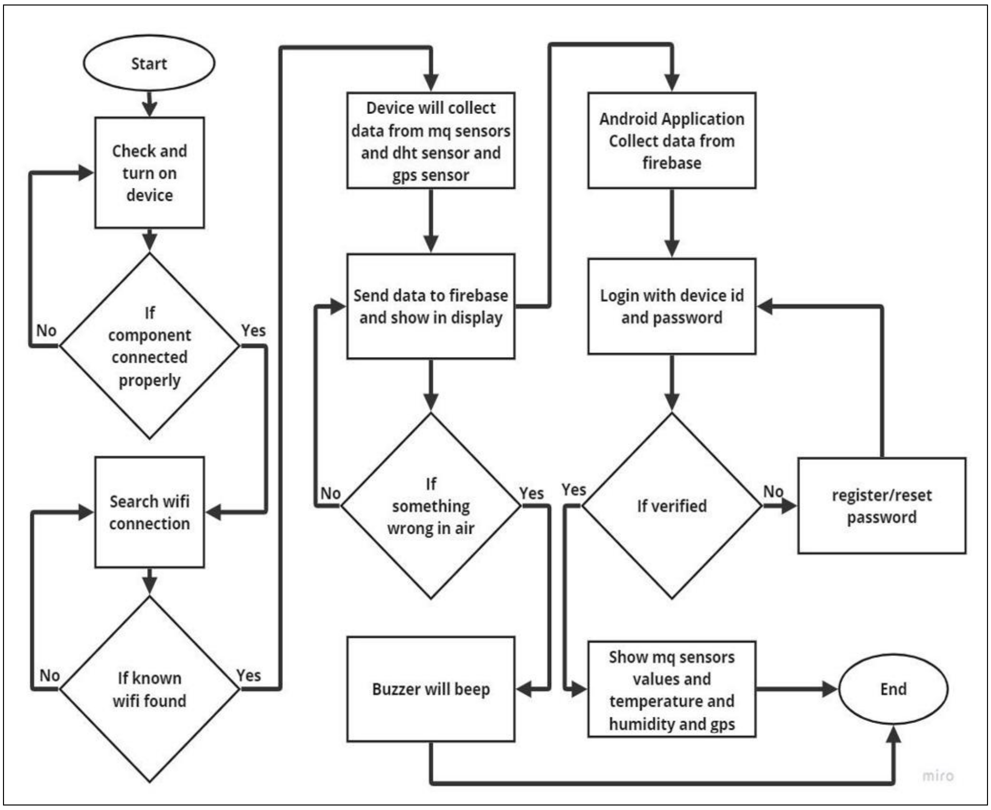

Fig 4: Data Flow diagram of proposed system

Description of the flow chart

Check the command when the gadget boots up, then turn it on. It will look for Wi-Fi if all the parts are connected correctly; if not, it will attempt to switch on. The gadget will establish a Wi-Fi connection if a known SSID is discovered. If not, it will function as an access point that the user may connect to in order to store wireless data. After that, the gadget will compile data from every sensor, transmit it to Firebase, and display it. The gadget will beep if there is a problem. Data from Firebase will be gathered and displayed by the Android application. The user must log in to view the data. The user can view data if they have been validated; if not, they must register and log in again. The procedure will then be finished.

Circuit Diagram

A circuit diagram is a visual depiction of the pin arrangements in an electrical circuit. Simple pictures of the components are used in pictorial circuit diagrams. The suggested systems by the author are represented graphically and connected in the circuit diagram that follows.

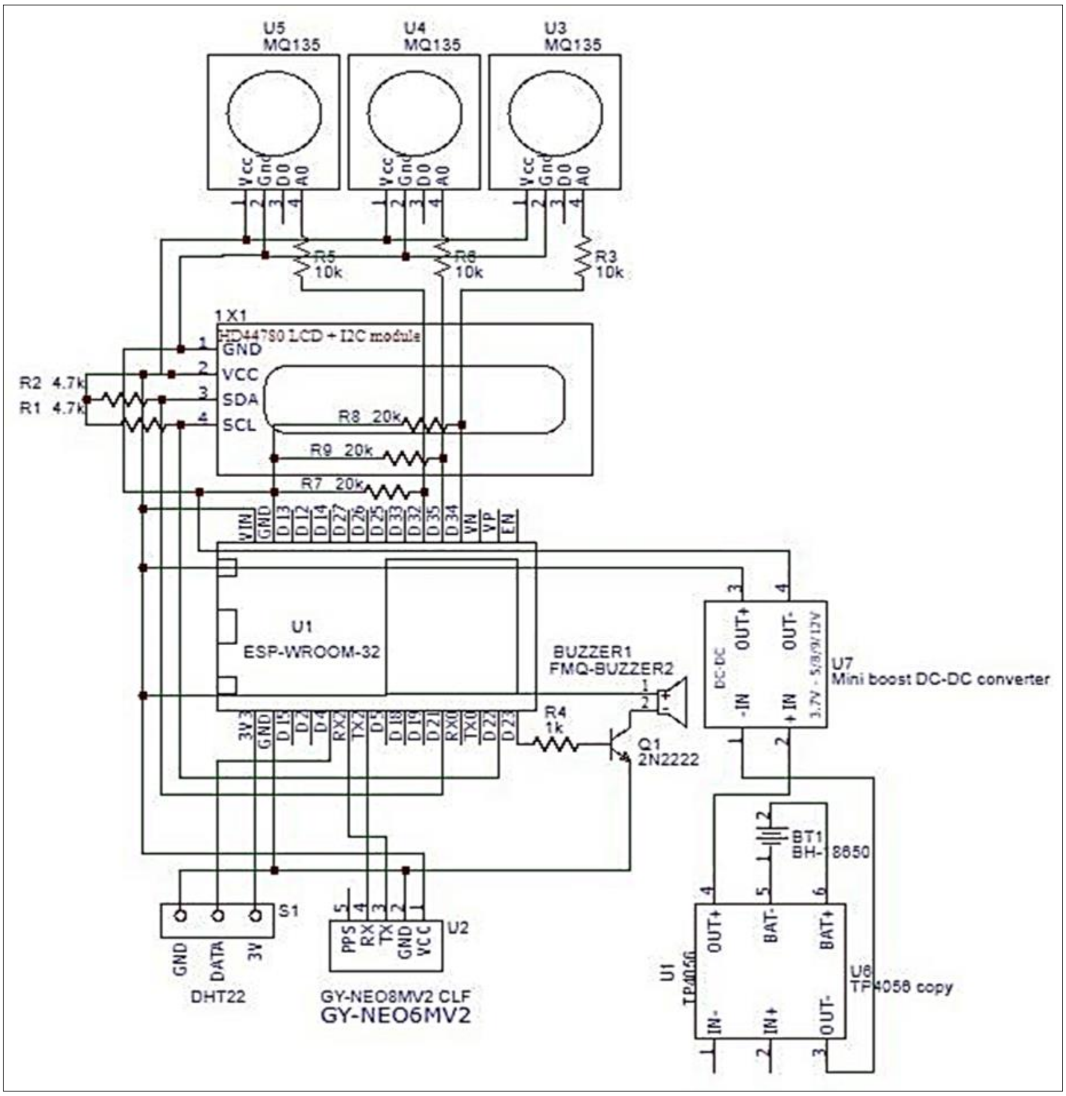

Fig 5: Circuit Diagram of the proposed device.

Description of circuit diagram

In this circuit Ground or Negative is common connection.

MQ2 sensor VCC connect with +5v, Ground in common, A0 pin connects with D32 pin with 10K resistor series and 20k pulldown resistor esp32 pin.

MQ7 sensor VCC connects with +5v, Ground in common, A0 pin connects with D35 pin with 10K resistor series and 20k pulldown resistor esp32 pin.

MQ135 sensor VCC connects with +5v, Ground in common, A0 pin connects with D34 pin 10K resistor series and 20k pulldown resistor with esp32 pin.

I2c LCD VCC connects with +5v, Ground in common, SDA pin connects with D21 with 4.7K pullup resistor esp32 pin and SCL pin connects with D22 with 4.7K pullup resistor esp32 pin.

DHT22 sensor 3v connects with +3v on esp32, Ground in common, DATA pin connects with D4 with esp32 pin.

NEO 8 GPS module VCC connects with +5v, Ground in common, RX pin connects with TX2 pin and TX pin connects with RX2 pin of esp32 pin.

For buzzer output Buzzer positive pin connect with +5v in circuit and negative connects with 2N2222 transistor collector pin where emitter pin connects with common ground and base pin connects with D23 pin of esp32 with 1k resistor in series.

In the power section, there is a battery lithium ion battery. To charge and discharge, there is a module based on TP4056.The circuit needs +5vs, which is why there is a mini-boost module. To operate whole circuit, there is a switch to control power section.

Project Description

Device Prototype

All module has all shown in figure 6. This is the prototype built to achieve the goal. The system state will be restored once we give it before power, establish a network connection.

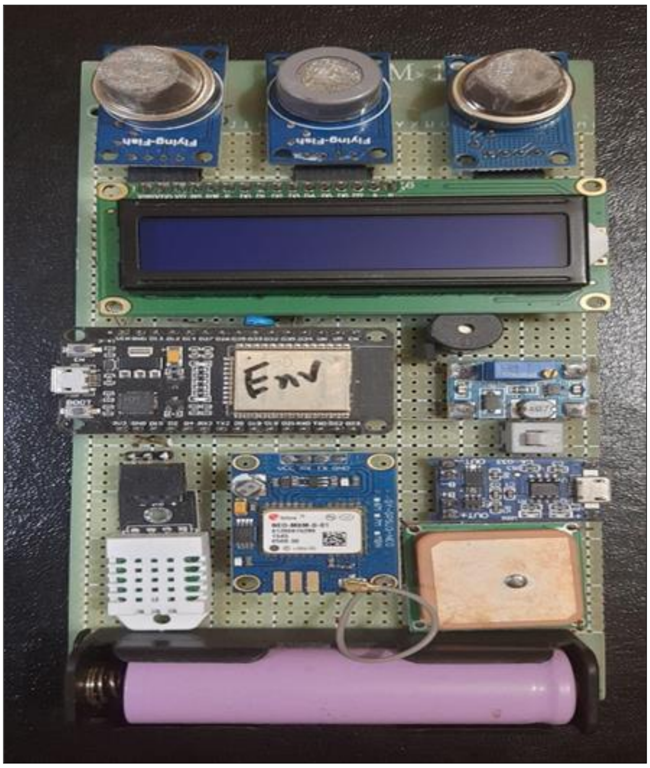

Fig 6: Device Prototype.

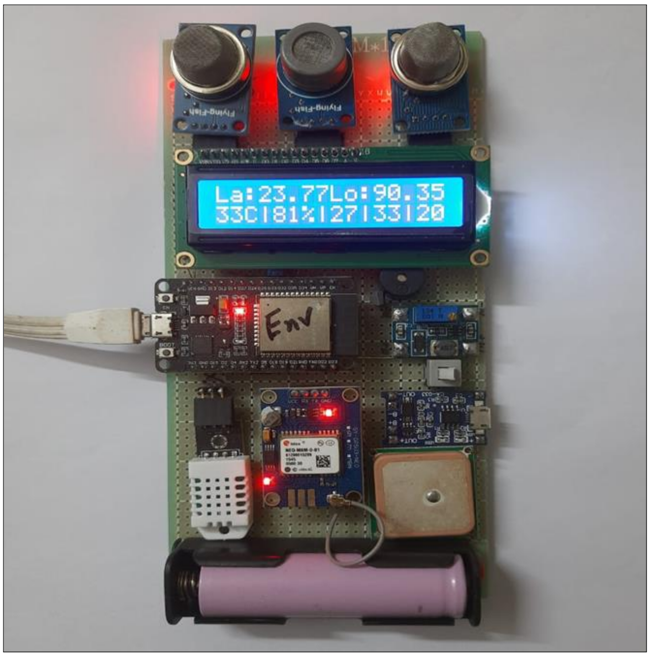

Fig 7: When the prototype is in on mode.

Description of device prototype

As soon as we provide the system electricity and establish a network connection, the system state is restored. This gadget will observe the system by logging onto mobile. When all sensors are connected to the ESP32, it becomes a special environmental monitoring tool. This gadget is the result of the combination of hardware and software. The device's hardware is made up of five sensors: an LCD display, a buzzer, a button, a Mini DC-DC booster module, an ESP 32 Microcontroller (Bluetooth and Wi-Fi) module, three MQ gas sensors (MQ2, MQ7, and MQ135), a NEO 8 GPS module, and an LCD sensor for temperature and humidity. The humidity and ambient temperature will be measured via the DHT-22 sensor. The Neo8 GPS module, often referred to as the U Block M8 competitor GNSS, may either truck down or display the latitude and longitude information based on the device's current position. The MQ2 Gas Sensor is a smoke-sensitive device that can detect a variety of gases everywhere. It can detect combustible gases including methane (CH4), butane, propane, alcohol, and LPG. The MQ7 sensor measures the amount of carbon dioxide (CO2) in the air and is a carbon monoxide (CO) gas detector. The MQ 135 sensor can identify hazardous or poisonous gases present in the atmosphere. The MQ, MQ7, MQ135, and DHT2 sensors are all linked to the ESP 32 Espressif microcontroller board in this setup. The ESP32 microcontroller board and the I2c LCD display together provide real-time data from all sensors as well as GPS latitude and longitude readings. A speaker that may proclaim or notify for range is called a buzzer.

Login

In the login interface, the user can install the Android application in mobile themselves by filling in the device ID (14484072) and password (*****). If login fail then click register/change button to update information.

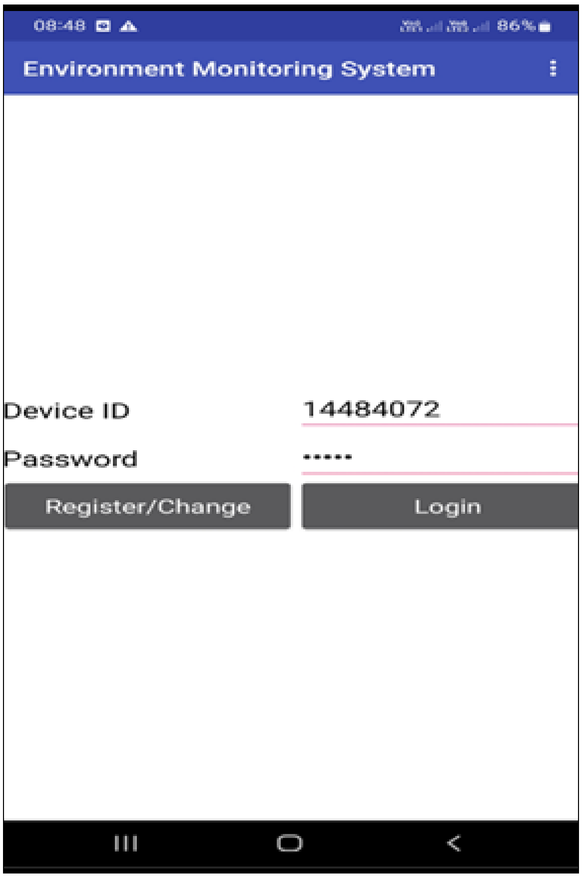

Fig 8: Login Interface of Android app in mobile.

Dashboard Interface

Dashboard interface at android app

In dashboard interface, the user can see all the data at kodular IoT Android App on Mobile including temperature, Humidity and gas sensor data.

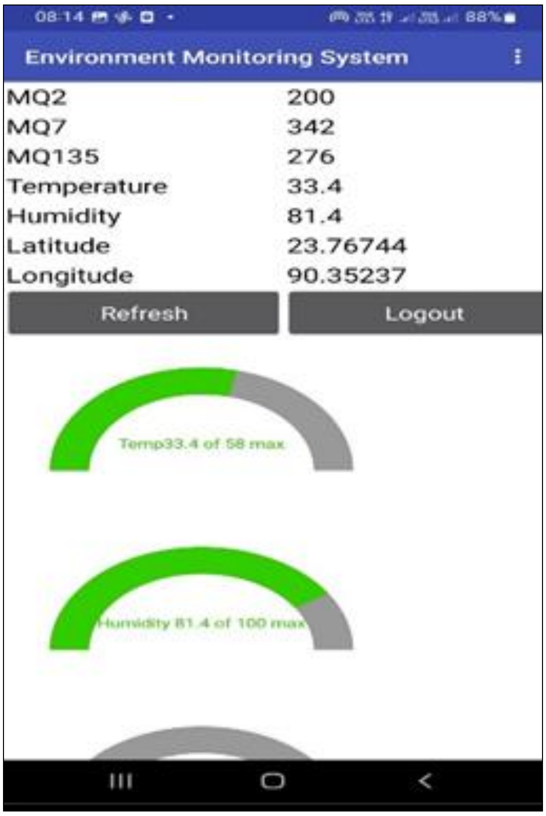

Fig 9: Dashboard Interface at Android app of proposed system on mobile

Notifications and Alerts

It will send notifications and alarms when the temperature, humidity, MQ2 gas sensor, MQ7 gas sensor and MQ135 gas sensor are outside of range. Please check the internet connection before relying on the notice, which provides the temperature, humidity, MQ2 gas sensor, MQ7 gas sensor, MQ135 gas sensor value.

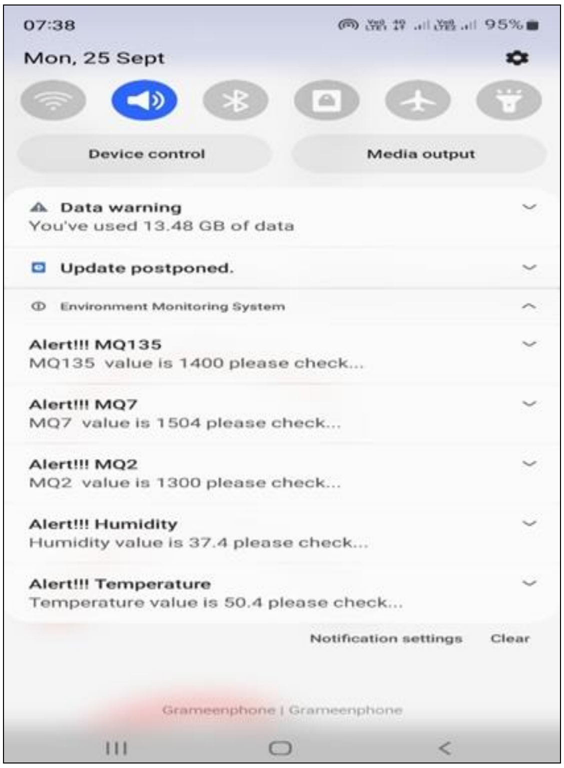

Fig 10: Dashboard Interface of Android app for notifications & alerts on mobile.

Firebase Interface

The desktop will indicate a real-time database when the Firebase cloud server is accessed. The following screen will provide all project overviews, including an exhaustive list of all sensors, real-time data, and date & time.

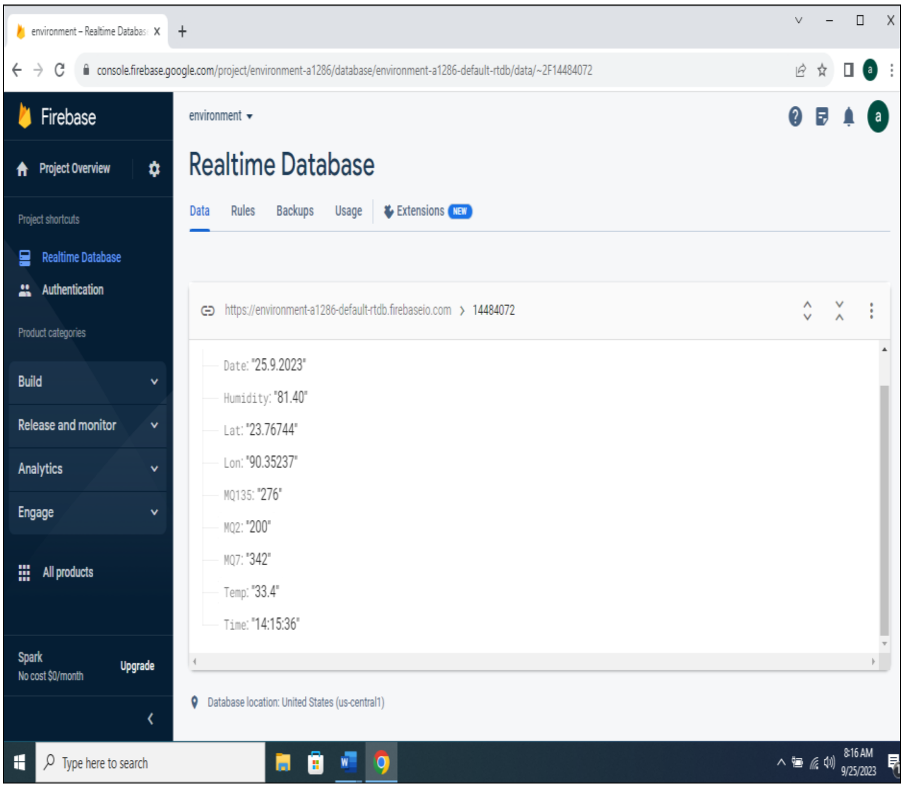

Fig 11: Firebase Interface of proposed system on Desktop.

Conclusions

An important Internet of Things application is environmental monitoring, which entails keeping an eye on the surroundings and transmitting data for efficient, short-term evaluations and assessments. The results and implementation details of an environmental monitoring system are presented in this study. A central Node MCU ESP 32 microcontroller board makes up the system. It interfaces with a temperature and humidity monitoring sensor DHT22 at the input, and an ESP 32 Wi-Fi module at the output. The ESP 32 Wi-Fi module transfers the detected data to an open IoT API Firebase for monitoring cloud storage through the Internet. Kodular analytics are performed on data using Firebase, and triggers are created. The Android operating system is used to construct a mobile application, and Firebase is used to retrieve data for user display from anywhere in the globe. The created system is inexpensive and provides insight into the planning and execution of a whole Internet of Things application, including everything from cloud storage and data retrieval through a mobile application through sensing and wireless transmission. The app provides the user with real-time data, allowing them to view temperature, humidity, and gas sensor data. They may gauge whether or not their surroundings are healthy for them by looking at these facts. Should the device detect any data from the temperature, humidity, or gas sensor that deviates from the expected range, the user will additionally receive an alarm signal from the system. This is definitely a benefit. We can promptly take the appropriate action once we get the notification. The device's overall performance is acceptable and appropriate for everyday usage.

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