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Original Article

Internet of Things and Cloud Server-based Indoor Talking Plant

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Abstract** - Human health, well-being, and comfort correlate directly with an interior environment. As a result, indoor climate control and monitoring are commonplace in a variety of settings, including homes and public buildings. Our prior studies have demonstrated that an active talking plant pot system may efficiently lower particulate matter and volatile organic compound concentrations while stabilising carbon dioxide levels in an indoor setting. The real-time monitoring of plant health has gained significant attention related to the indoor environment. In this study, we have proposed a system with Wi-Fi & mobile application to monitor pot plant health using in the indoor environment. We have developed customised hardware with multiple sensors and communication protocols to realise the proposed system. Further, this hardware is deployed in the plant pot with sensors to log sensor values on cloud server-based web and mobile applications. This study is used to propose a system for monitoring the health of plants and indoor climates. This also helps those who do not have time to water the plant also.

***Keywords** - Arduino uno, ATmega328P, ESP8266 (Wi-Fi), Soil moisture sensor, DHT11, Water pump, LCD screen (20x4).*

1. Introduction

Many conventional applications are now being digitalised thanks to the developing Internet of Things (IoT) and cloud technologies. IoT and cloud technologies have been promoted for use in industrial applications through various theoretical and analytical studies [1], [2]. Green plants enhance interior climates and lower energy usage in addition to providing initial visual ornamentation. They do this by evaporating, purifying the air, and holding onto water [3] [4]. We anticipate that the remotely managed and monitoring system built with the help of IoT and cloud platform would work as a workable alternative. Remotely monitored solution based on cloud service and investigated in a wide field range, including industrial monitoring [5], health care [6], [7] and pain monitoring [8], monitoring of traffic [9], car parking [10], irrigations in agriculture [11], and environment monitoring [13,49]. These solutions were developed from the networks of sensor integration and cloud infrastructure.

In accordance with World Health Organization, the phrase "indoor climate" refers to the temperature, atmospheric, auditory, actinic, and mechanical conditions of commercial, public buildings, or residential (WHO). The health of humans, perceived well-being, comfortable, and job productivity are all strongly correlated with the temperatures, quality of air, humidity, & conditions of lighting of an interior environment [14]. Numerous studies have been done to show the effects of living in a polluted indoor environment on people [15]. As a result, the indoor environment has seriously affected the safety and health of individuals. The vertical plant wall system is one of several commercially available items and solutions that have been created to enhance indoor climates [16]. Most of the time, people spend their time indoors [17]. It makes the interior environment's quality crucial for people's health and well-being. In fact, there is a connection between the standard of interior surroundings and people's health, productivity, comfort, and overall quality of life [18].

The health of humans is tied to their indoor environment. Planting potted plants is one of the best ways to improve the indoor atmosphere [19]. Usually, people do not water their plants enough. The system occasionally has responsibilities, including extended business trips or working outside their house, causing difficulty properly caring for trees. Some people might have to spend more to employ a gardener while they are gone from the house for a long period of time. Using a water hose or watering can inject water into the soil of each tree is the traditional way to irrigate plants. This approach could be problematic for seniors who prefer to plant several trees. The elder's physical state might be badly impacted by standard practices like leaving them exposed to the sun for a long, hot day to water the plants. With the motivation from the above facts, this study proposed IoT-based hardware for realising the talking plant pot with the cloud server and IoT connectivity. The proposed system can detect water content, temperature, and humidity and control the water pump through internet connectivity. In addition to this, an audio device is integrated to generate audio regarding the water content based on sensor data. The contribution of our study is as follows:

- Scalable cloud-based architecture is proposed for real-time monitoring and visualisation of the plant pot through the multitude of sensors and internet connectivity.
- Customised hardware is developed by integrating ATmega 328 and a Wi-Fi board to realise the proposed architecture.
- The customised hardware is integrated into the smart pot and implemented in real-time for the health monitoring of the plant and automatic alerts generation and also controlling of the water pump for watering the plant.

The remaining study is organised as follows: Section II examines the literature's current solutions and system needs. We present our recommended system and work in Section III. The section describing the hardware is found in Section IV. The programme description is described in Section V. Section VI provides the suggested system's outcomes and shows how it was implemented. The paper is wrapped up in the final part.

2. Review of Literature

A study has proposed a pot which it has the ability to recognise the presence of water and sunlight and generates sound if it needs water and sunlight through water level and LDR sensor [22]. Study [19], the soil moisture and light data are collected & fed back to the main controller. System supplemental light by employing drip irrigation to provide water and the Pan/Tilt/Zoom module to receive more light than outdoor growing plants. Additionally, this system uses red, blue and UVB for better growth and makes this study possible to control succulent plants intelligently via a wireless network. Using the mobile application can measure and display the temperature and soil moisture content through which users can monitor the temperature and moisture content.

The application will notify the user if the moisture value becomes less, and the user can operate the water pump through the application [20]. The study has discussed the use of smart plants to monitor the interior environment using soil moisture, temperature, humidity, and CO2 sensors, and the author has concluded that smart plants may be used to estimate total CO_2 buildup and occupancy data [23]. A remote monitoring and control system proposed for plant walls uses the IoT and the Azure public cloud platform to automate the maintenance to remote a healthy indoor environment [24].

An author in a study proposed a monitoring system for houseplants, including soil moisture, temperature, and light intensity and used an SMTP-based system for interaction with the owner with remote help. In addition, several power-saving features are included at hardware and software levels to increase battery life [50]. Nilesh Kuchekar et al. proposed an autonomous system installed in the plant's root zone for real-time in-field sensing, including wireless humidity, soil moisture, and temperature sensor. Using GSM and zig-bee, data is sent to the mobile application of the user [25]. The author proposed a solution to minimise water wastage by continuous soil condition monitoring by using GSM to collect moisture and temperature sensor data; these all are managed by sending a message from a phone [25]. The fundamental elements of a cloud-based environmental motion monitoring architecture were theoretically studied in [26], which also presented the design.

In the studies [27, 28, 30, 31, 51] and [32]–[35], ZigBee-based networks of wireless sensors for monitoring indoor air quality were examined. An isolated and control system was proposed to improve indoor air quality and lighting quality, in which CO2 & illumination collected data were used to manage the exchange of air and lighting quality [36]. The author used a sink device linked to a local computer to gather and spread ZigBee data and store it in a local database. To see classified sensor data, a GUI program was created. To integrate the control of HVAC systems, a framework was proposed to put out but never put into practice [30]. Pitarma et al. developed a technique. Using a MySQL database to track indoor air quality and using a ZigBee sensor network gateway to continuously transmit environmental data using Restful web services to a private server [27]. Yang et al. made a private cloud server. They built a computing application in OpenStack based on Hadoop and iEDMS cloud and analysed environmental data in HBase to increase the cloud server stability [32]. A solution proposed to make use of commercial visualisation services is suggested in [37] and [52]. The study suggested a remote monitoring option for situations like wineries and creameries. A microcontroller regularly reads the sensor data and sends it to a server. Using a commercial visualisation platform called PI, all sensor data can be seen on a webpage [37].

Table 1. Specifications of ESP8266 (Wi-Fi) [39]

Parameters	Specifications
Protocols	802.11 b/g/n (HT20)
Frequency Range	2.4 GHz ~ 2.5 GHz (2400 MHz ~ 2483.5 MHz)
TX Power	802.11 g: +17 dBm 802.11 b: +20 dBm 802.11 n: +14 dBm
Rx Sensitivity	802.11 n: –72 dbm (MCS7)
	802.11 b: –91 dbm (11 Mbps)
	802.11 g: –75 dbm (54 Mbps)
Security	WPA/WPA2
Network Protocols	IPv4, TCP/UDP/HTTP

An IoT & cloud-based pain monitoring system was proposed by Yang et al., which has a node of the sensor in the face mask to check any discomfort of the patient, including User Datagram Protocol (UDP) and a gateway embedded with Wi-Fi module (TCP) to communicate data with mobile and web application to do real-time analyses [8]. The author wants to obtain data from medical equipment via mobile phone by using Bluetooth, then transfer via Wi-Fi to a rich Internet application (RIA), and Ali public cloud platform was created [13]. A system was proposed to gather humidity, light intensity, temperature, and volume of dust percentage data; the author suggested an indoor monitoring system, which includes Linklt One board as local hardware and Wi-Fi to deliver the information into Yeelink. With the help of this, administrators and end users may monitor the indoor status [52].

2.1. Overview of ESP 8266

A Tensilica microprocessor of 32-bit, interfaces of common digital peripherals, antenna switches, RF baluns, powered amplifiers, amplifiers of low noise receivable, modules for power management and filters all are included in the system-on-chip (SoC) known as ESP8266EX (often abbreviated as ESP8266). The specifications of ESP8266 (Wi-Fi) is given in Table 1. Wi-Fi (802.11 b/g/n, supporting WPA/WPA2) at 2.4 GHz, general-purpose input/output (16 GPIO), Inter-Integrated Circuit (I2C), analog-to-digital conversion (10-bit ADC), Serial Peripheral Interface (SPI), I2S interface with DMA (sharing pins with GPIO), UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2), and (PWM). Espressif's "L106" core processor, which operates at 80 MHz, is based on Tensilica's Diamond Standard 106Micro 32-bit processor controller core (or overclocked to 160 MHz). It features an 80 KiB user data RAM, 64 KiB boot ROM, and 32 KiB instruction RAM. (Additionally, 16 KiB ETS system data RAM and 32 KiB instruction cache RAM.) Through SPI, external flash memory may be accessed. A 5 mm Quad Flat No-Leads box with 33 connection pads, including 8 pads along each side and a large thermal/ground pad in the centre, houses the silicon chip itself [39].

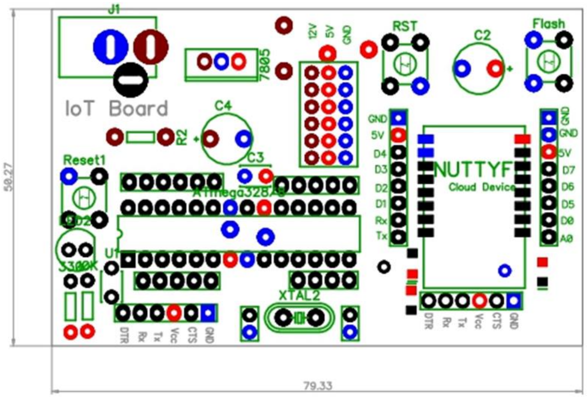

Fig. 1 Customised IoT board

3. Hardware Implementation

Here we will discuss the importance of customised hardware implantation of a computing unit Arduino uno and node MCU ESP8266 (Wi-Fi) for real-time monitoring of indoor plant health conditions. Here the computing unit is mainly ATmega328P, additionally ESP8266 for data communication with a user with the help of an internet connection. Firstly, designing and cost of the system become the priority because it is installed indoors only, and raspberry pi cannot be used; otherwise, it will increase the cost of the system, which may go beyond the normal price.

Here we have used a customised board which is a combination of Arduino uno board and node MCU Esp8266, and we gave a name to this as IoT board, and this board contains two-way programming pins, one for ATmega328P and one for node MCU ESP8266 (Figure 1). This board is customised to overcome the connections because otherwise, Arduino uno and ESP8266 require an additional connection. An Arduino uno board has only 14 digital and 6 analog pins, which may limit the pins for connecting the remaining sensors and other components.

In this customised IoT, the board have additional power pins; several separate pins are present for power, and they are GND, 5V, and 12V pins. This customised IoT board increased component flexibility as per our requirements. Then we installed voltage regulators in the board for different power supply requirements to the different components like for water pump(motor) 12V, sensor node 5V, etc. Additionally, we provide a heat sink to the voltage regulators. For the water pump (motor) 12V, we used a 12V relay to reduce the motor's back emf, which can bring damage risk to the customised IoT board, as shown earlier in the diagram. Moreover, the most important thing is because of Atmega328P controller uses the least amount of current, around milliamperes (mA), for calculating the data, so we chose it [48].

Then we brought the SD Card, SD Card Module and Audio Jack (3.5mm) to run the speaker. We customise a separate board with components SD Card, SD Card Module and Audio Jack (3.5mm) to run the speaker; this SD Card is used to store audio statements, which will run according to the pot plant condition. Moreover, the speaker is combined with an external power source to reduce the power load on the customised IoT board. Otherwise, more power load may lead to overheating the board, which may not work properly.

3.1. Computing Unit (Arduino Uno)

Due to its widespread acceptance by the general public and appeal, Arduino Uno serves as the microcontroller in our solution. Either an AC-to-DC converter with a 6-20 V power source or a USB cable may power it. The ATmega328P chip is the foundation of the Arduino Uno board (Figure 2). Six of the board's six analogue input pins and 14 input/output digital pins can be used as PWM pins for outputs. I2C, SPI, and UART serial communication are all supported by the ATmega328P. Since it has a robust I/O & interface of communication, Arduino Uno is a dependable option for regulating sensor readings [24]. The specifications of ATmega328P is given in Table 2.

3.2. LCD Display (20x4)

An electronic visual display, flat panel display or displayed video that takes advantage of modulating of light capabilities of liquid crystals is known as a liquid-crystal display (LCD) (Figure 3). Liquid crystals do not directly emit light. 80 Characters of the total can be displayed at once thanks to the 20x4 format, which allows for the display of 20 characters in each of the LCD's 4 rows [41].

3.3. LCD Breakout Board

A "dumb" board is the LCD breakout board (Figure 4). The LCD module is essentially merely connected to pin headers for simpler connectivity during prototyping. In order to decrease the number of headers needed, some of the pads and pins are linked together [42].

3.4. Soil Moisture Sensor

A soil moisture sensor is one type of inexpensive electrical sensor used to measure soil moisture (Figure 5). The Sensing Probs and the Sensor Module are the two primary components of this sensor. The probes enable current to flow through the soil, and they subsequently calculate the resistance value based on the soil's moisture content. The Sensor Module receives data from the sensor probes, analyses it, and outputs the result as either a digital or analogue signal [43].

3.5. SD Card Module and 3.5mm Audio Jack

One of the most crucial components of every project is data storage. Depending on the kind and amount of the data, there are several methods for storing it. One of the most useful storage options is SD and micro-SD cards (Figure 6) used in mobiles, minicomputers, and many other similar products. You may interface with the memory card and read or write data using the SD and mini-SD card modules. The SPI protocol for connecting the SD card is used in Figure 6.

3.6. Speaker

The speaker is one of the output devices most frequently utilised with computer systems (Figure 7). While some speakers are created expressly for use with computers, others may be connected to any kind of sound system. No matter how they are made, speakers are meant to provide audio output that the listener can hear [45].

3.7. Node MCU ESP 8266

The ESP32 (Figure 8) family of systems on a chip microcontroller features built-in dual-mode Bluetooth and Wi-Fi. The Tensilica Xtensa LX6 microprocessor is used in the ESP32 series, which also has built-in switches of antenna, power amplifiers, filters, RF baluns, low noise receive amplifiers and modules for power management. Chinese business Espressif Systems, with headquarters in Shanghai, invented and constructed the ESP32, which is produced by TSMC using their 40 nm technology [20].

3.8. SD Card

The SD Card Association (SDA) created the Secure Digital (SD) and non-volatile memory card (Figure 9) format for usage in portable devices. As an upgrade over Multimedia Cards (MMC), SanDisk, Panasonic (Matsushita Electric), and Toshiba jointly established the standard in August 1999. Since then, it has emerged as the industry norm [46].

3.9. Temperature and Humidity Sensor (DHT11)

The Grove DHT11 sensor (Figure 10) offers pre-calibrated digital output and ensures long-term dependability measures temperature and relative humidity (RH). A capacitive sensor element measures humidity, whereas a negative temperature coefficient (NTC) thermistor measures temperature. In an interior environment, the RH of 20-50% and temperature of 0–50°C measurement ranges are adequate [24].

3.10. Water Pump

The fundamental idea behind a water pump (Figure 11) is to utilise a motor to transform rotational or kinetic energy into power for fluid motion or flow (hydrodynamic energy). An impeller is used in centrifugal pumps; fluid enters via the revolving impeller and is ejected out by centrifugal force through the tips of the impeller [47]. Reminder: Avoid running the pump dry (without submerging it in water) and refrain from pumping combustible substances [20].

3.11. Adapter

We have used the adapter (Figure 12) for giving external power to our proposed prototype, which is with INPUT-240V, OUTPUT- 12V/2A and MODEL- AC Adapter.

Table 2. Specifications of ATmega 328P [40]

Characteristics	Specifications
Controller	8-bit microcontroller
Architecture	RISC
Programming	In-system programming
PWM	Channels 6
Pin	6 analog pins, 14 digital pins
Current active state	1.5 mA at 3 V-4 MHz,
Power-down state	1µA at 3 V
Operating volt	2.7 V to 5.5 V
Serial interface	Master/slave SPI
Characteristic	Specification

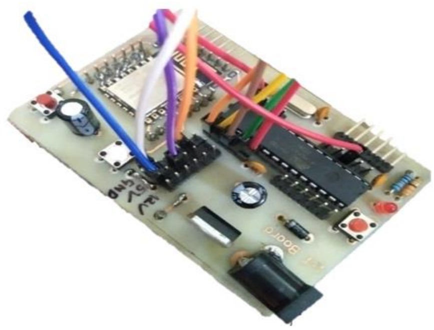

Fig. 2 Customised Arduino board (ATmega328P) with node MCU ESP328

Fig. 3 LCD display (20x4)

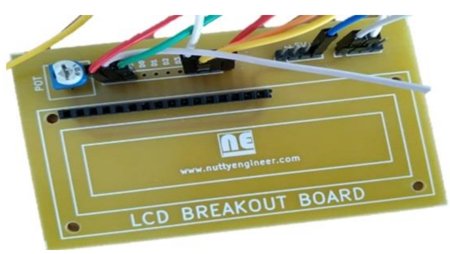

Fig. 4 LCD Breakout board with connections

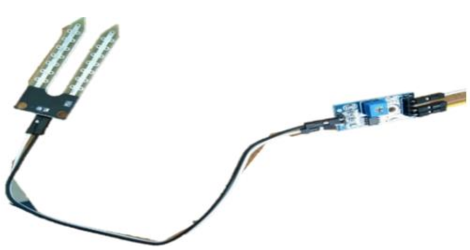

Fig. 5 Soil moisture sensor with sensing probe and sensor module

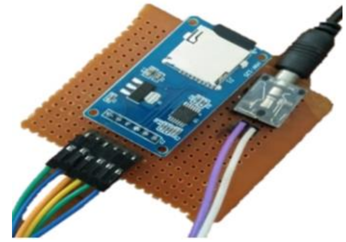

Fig. 6 SD card module with connections and (3.5mm) audio jack

Fig. 7 Speaker, which we have used in our prototype

Fig. 8 Node MCU ESP 8266 (Wi-Fi)

Fig. 9 SD card we have used in our prototype

Fig. 10 DHT11 (Temperature and humidity sensor)

Fig. 11 Mini water pump we have used in our prototype

Fig. 12 Shows the picture of the AC adapter used in our work

3.12. Double Channel Relay

Simply put, it is an automated switch to a low-current signal regulating a high-current circuit. It is widely used in power protection and communication equipment, as well as electromechanical and power electronic ones. Induction components included in relays often reflect input variables, including voltages, currents, resistance, frequencies, powers, speed, pressure, light, and temperature, among others. Additionally, it has an actuator (output) module that can activate or de-energise a regulated circuit connection. Between the input and output parts, an intermediate component is utilised to couple and actuate the output while isolating the input current. The regulated output circuit of the relay will be activated or deactivated when the input's rated value (current, temperature, voltage, etc.) exceeds its critical value [20]. The double channel relay module is given in Figure 13.

Fig. 13 Double channel relay module, which is used in our prototype

Fig. 14 Created template in the blynk application

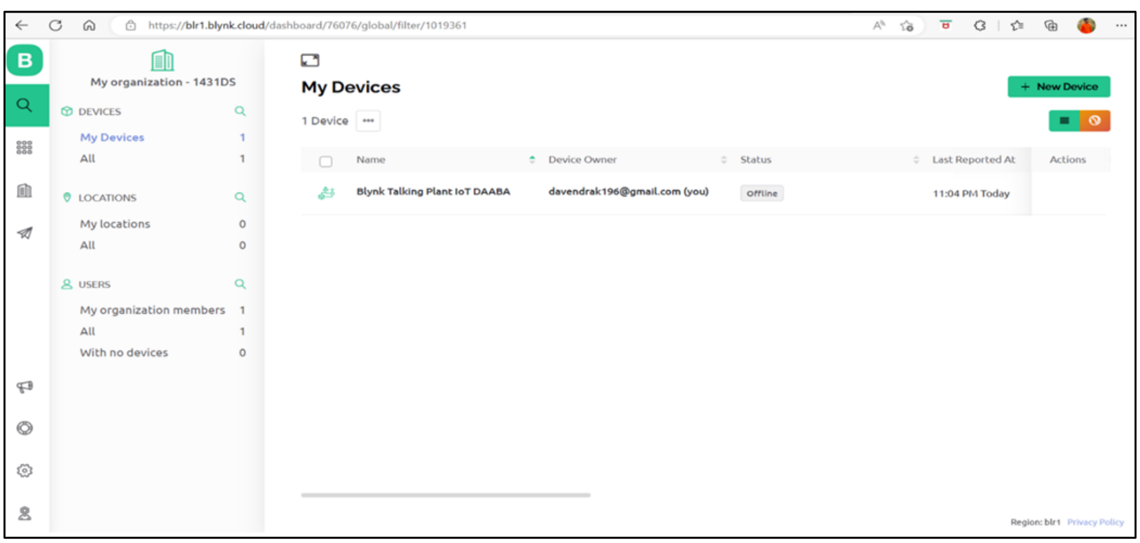

Fig. 15 My device name in the Blynk application/software

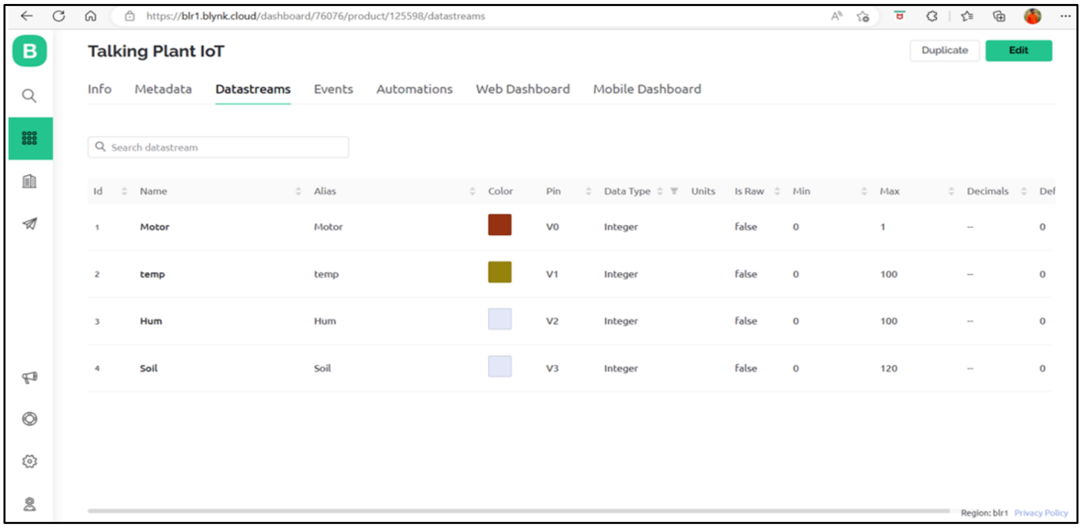

Fig. 16 Data stream of our prototype

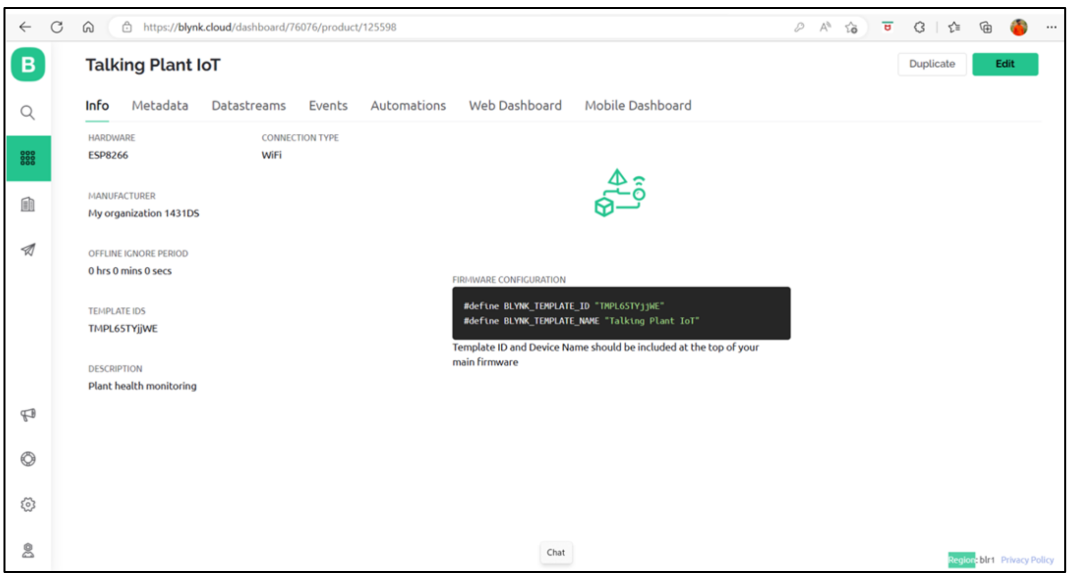

Fig. 17 Prototype information in the blynk application

4. Software Description

4.1. Blynk Application

Firstly, we made an account, logged in, and created a new template, as shown in Figure 14; then, we customised this template to add buttons and gauges to show the values/data collected by sensors in the soil of the plant pot. Then after creating a template, we can see in my device also, as shown in Figure15. After this, we customised the template by creating the following button and gauges, as shown in the Figure 16.

1) Button for Water pump (motor) to go on/off from a mobile application or from a web application that is from a PC/Desktop and is connected as a virtual pin (V0).
2) Gauge for showing the value of temperature (temp) by temperature and humidity sensor that is DHT11 on the screen and is connected as virtual pin (V1).
3) Gauge for showing the value of humidity (Hum) by temperature and humidity sensor that is DHT11 on the screen and is connected as virtual pin (V2).
4) Gauge for showing value of soil moisture sensed by soil moisture sensor (soil) on the screen and is connected as virtual pin (V3).

Here in this Figure 17, we have shown our prototype information as shown in the blynk application that is, Hardware: ESP82666, Manufacturer: My organisation: 431DS, Offline Ignore Period- 0 hrs. 0 mins. 0 secs., Template Ids- TMPL65TYjjWE, Description- Plant health monitoring, Connection Type- Wi-Fi and Firmware Configuration.

```
#define BLYNK_TEMPLATE_ID “TMPL65TYjjWE”
#define BLYNK_DEVICE_NAME "TALKING PANT IoT"
#define BLYNK_FIRMWARE_VERSION      “0.1.0”
```

```
#define BLYNK_PRINT Serial
#define USE_NODE_MCU_BOARD
#include "BlynkEdgent.h"
#include <SoftwareSerial.h>
const byte rxPin = D6;
const byte txPin = D7;
SoftwareSerial mySerial (rxPin, txPin);
Int sensorPin = A0;
Int sensorValue;
Int limit = 100;
BLYNK_WRITE(V0)
{
    Int s0 = param.asInt(); // parameter as int
    If(s0==HIGH)
    {
        digitalWrite(D5,HIGH);
        delay(10);
    }
    else
    {
        digitalWrite(D5,LOW);
        delay(10);
    }
}
Void data()
{
    If   (mySerial.available()<1)   return;
    Char  R=mySerial.read();
    If   (R!='\r')                  return;
    int  temp=mySerial.parseInt();
    int hum=mySerial.parseInt();
    int soil=mySerial.parseInt();
    Serial.print(temp);
    Serial.println(hum);
    Serial.print  (soil);
```

Fig. 18 Code for interaction between ATmega 328P and node MCU ESP8266

```
#include <SoftwareSerial.h>
const byte rxPin = 6;
const byte txPin = 7;
SoftwareSerial mySerial (rxPin, txPin);
#include <LiquidCrystal.h>
LiquidCrystal lcd(A1,A2,A3,A4,A5,5);
#include "DHT.h"
DHT dht(2, DHT11);
#include "SD.h"
#define SD_ChipSelectPin 10
#include "TMRpcm.h"
#include "SPI.h"
TMRpcm tmrpcm;
int cntr=0;
int soil1;
int t,h;
int soil;
void setup()
{
    Serial.begin(9600);
    mySerial.begin(9600);
    tmrpcm.speakerPin = 9;
    dht.begin();
    lcd.begin(20,4);
    lcd.print("Talking Plant");
    pinMode(6, OUTPUT);
}
void loop()
{
    lcd.setCursor(0,0);
    lcd.print("Talking Plant");
    h = dht.readHumidity();
    t = dht.readTemperature();
    soil=analogRead(A0)/10.23;
    Serial.println(String("soil.")= soil);
    Soil1=map(soil, 35, 100, 100,0);
    Serial.println(String("Soil1.")+ soil1);
    lcd.setCursor(0,1);
```

Fig. 19 Code to run the speaker and show the values on the LCD display

Then the above firmware ID and name are copied and pasted on the top of our firmware code, and this is the code (Figure 18) which we have performed in our prototype. First, we have linked our prototype to the blynk application. This is an openly available application free of cost because it is difficult to make a new mobile application on our own, and it will also be very time-consuming. By using this application, we can see all the nearby environmental temperatures and humidity and soil moisture percent on the mobile screen itself. Then, through this coding, we put two pins into rx and tx, D6 and D7 pins.

Firstly, we program everything separately, and then we merge all the programs. And here, we have made pin 6 into rx and pin 7 into tx. In this program (Figure 19), we merge the program (Figure 20) for the speaker, LCD display, DHT 11, and Soil moisture sensor. In this program, we have connected the LCD on analog pins, i.e., A1, A2, A3, A4, A5, 5 and 5 is the digital pin. Here we have defined h for humidity for temperature and soil for soil moisture. Here we have divided the analogRead(A0) by 10.23 because the soil moisture sensor shows the values from 0 (zero) to 1023, so after division, it will show the value from 0 to 100, which is our requirement. This code is performed to run the statement in the speaker fitted in our prototype. Whenever the soil moisture level goes below 40%, then it will say, "I'm not happy; please help me", and whenever the soil moisture level goes beyond 75%, then it will say, "I'm happy now", and this statement is recorded in the SD card used here is 8GB which is operated through the SD card module. The speaker is connected here with an aux cable that is 3.5mm.

```
void spk()
{
   If(soil1<5)
   {
      cntr=1;
   }
   If((soil1>0)&&(soil1<=40))
   {
      cntr=1;
      if(cntr==1)
      {
        tmrpcm.play("sme1.wav");
        delay(3000);
        cntr=2;
      }
   }
   if(soil1>75)
   {
      If(cntr==2)
      {
        tmrpcm.play("sme2.way");
        delay(2000);
        cntr=3;
      }
   }
}
```

Fig. 20 Showing coding to run speaker with the statement

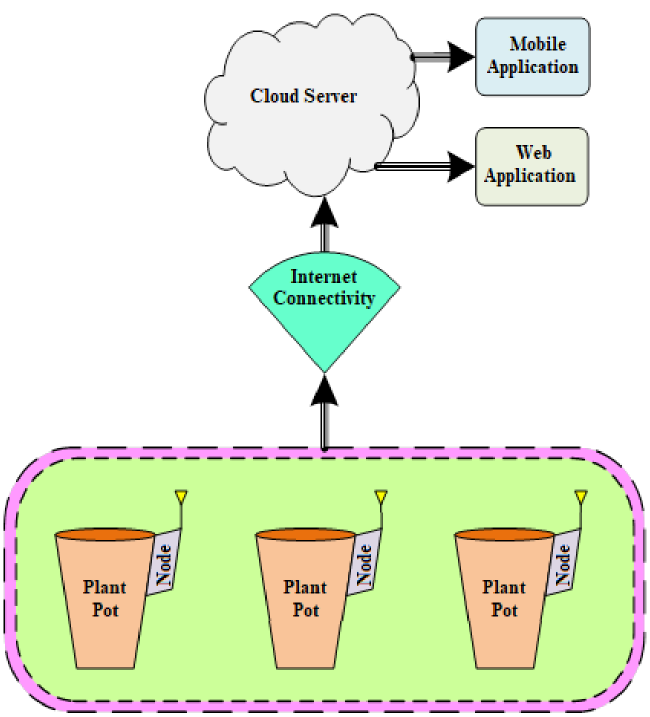

Fig. 21 Proposed plant pot working

5. Proposed System

It is a talking plant; in this Figure 21, the plant is planted in a type of pot which is automated. In this figure, we have shown that the main concept is a smart plant pot consisting of the plant pot, node and Wi-Fi connection to a server cloud through internet connectivity. That cloud is connected to a mobile app as well as a web application where we can see all details about soil on a mobile screen as well as on the laptop or desktop screen of these plant pots. Moreover, every pot has a unique code for identification in the cloud or mobile application. This is because if an owner has more than one pot, it will help him identify, as written before, and can connect the number of plant pots to the server at a time to monitor and maintain several plant pots simultaneously time.

In this Figure 22, we have shown the node constituents and working. Node consists of a computing unit, Wi-Fi, OLED or screen, speaker, battery, solar panel, and sensors (soil moisture sensor, temperature/humidity sensor, soil conductivity, NPK sensor and pH sensor). Here in this proposed system, we put all the sensors in the soil and connect them to the computing unit; the computing unit is connected to OLED, which shows all the values sensed by the sensors in the soil, as we can see in Figure 2.

The speaker is fitted with the computing unit to remind for watering and other requirements. Now the fitted Wi-Fi will send all the soil details/data to the cloud server, which can easily be seen in the mobile application. But the main thing is the power supply, so we also have developed the ultimate source of power supply, that is solar power; all the units will be connected to the battery, and the battery will be connected to the solar panel, which will charge the battery automatically in a continuous manner.

6. Results and Analysis

This proposed system will help monitor the health of the pot plant and will remind for watering also with the help of a speaker. All the essential soil values also can be seen on the LCD Display, like soil moisture percentage, humidity, temperature etc. Whenever the soil moisture becomes below the level of 40%, the alarm will start, and whenever the soil moisture percentage goes above 80%, then it will alarm again. And there is a motor pump in another container containing water for watering the pot plant.

And it can be operated on mobile, and all the essential soil values are uploaded to the cloud server and can be seen in the mobile application; it can be done on a large scale with unique identification ids of each and every plant pot because otherwise, it will be difficult to identify which plant pot have to give any treatment or water without any unique identification. And all these plant pots can be connected to each other; if a pot owner owns more than one plant pot, an alert will generate whenever the water in the pot plant soil moisture level decreases by a certain level. Now here in this figures, showing all the final combinations of our prototype (Figure 23) and the connections (Figure 24) are given.

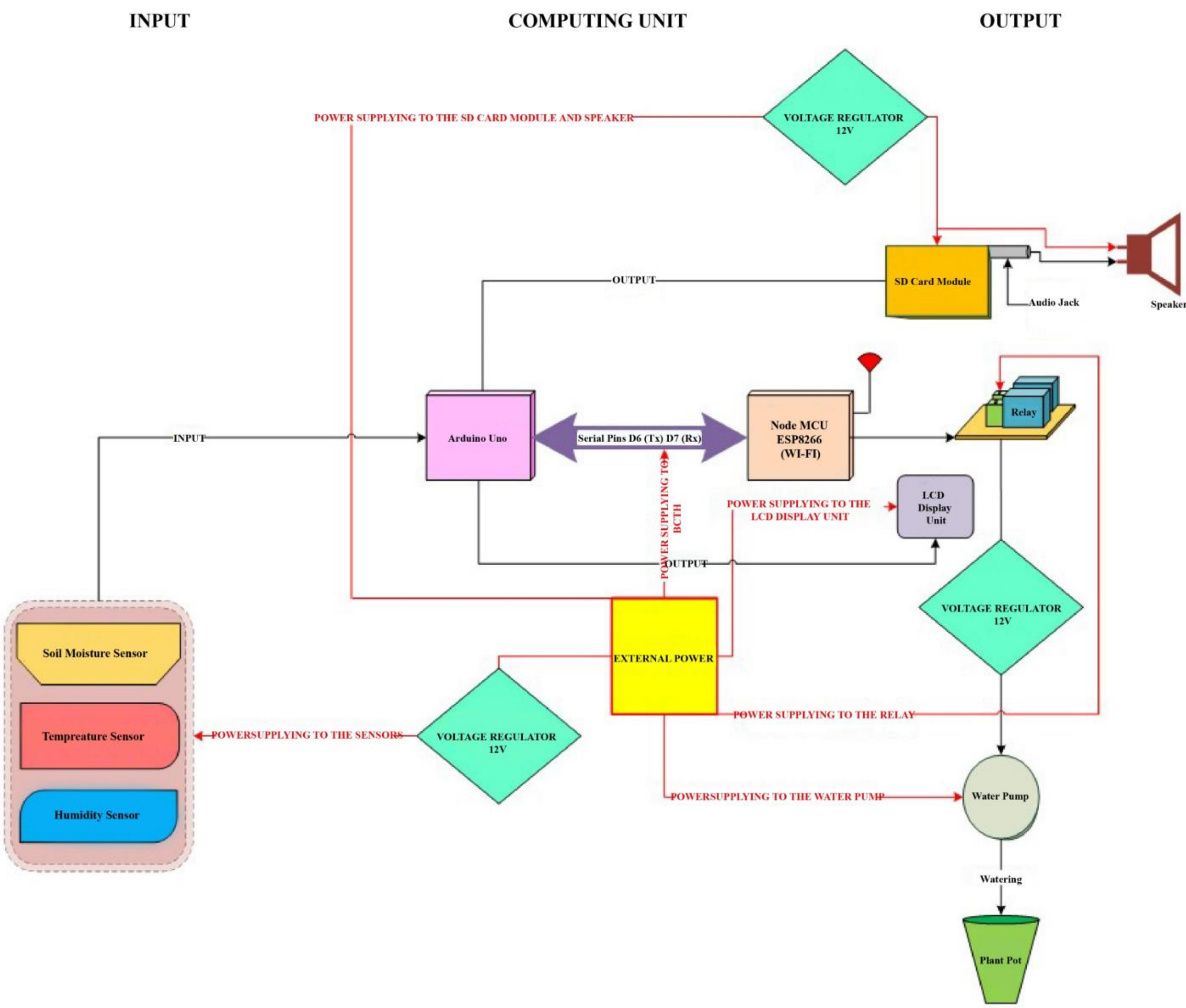

Fig. 22 Flowchart showing the working of a node of a plant pot

a) LCD Display (20x4): LCD RS pin to analog pin A1, LCD Enable pin to analog pin A2, LCD R/W pin to ground, LCD D4 pin to analog pin A3, LCD D5 pin to analog pin A4, LCD D6 pin to analog pin A5, LCD D7 pin to digital pin 5, LCD VSS pin to ground and LCD VCC pin to 5V.
b) SD Card Module: SD Card Module GND pin to Arduino GND, SD Card Module VCC to Arduino 5V, SD Card Module MISO pin to Arduino digital pin 12, SD Card Module MOSI pin to Arduino digital pin 11, SD Card Module SCK pin to Arduino digital pin 13. SD Card Module CS pin to Arduino digital pin 10.
c) Audio Jack: White wire to Arduino pin 9 and purple wire to Arduino pin GND.
d) Speaker: The speaker is connected through an aux cable to the 3.5mm audio jack and powered by an external power source.
e) Temperature and Humidity Sensor (DHT11): DHT11 pin DOUT to Arduino digital pin 2, DHT11 pin GND to Arduino pin GND and DHT11 pin VCC to Arduino pin 5V.
f) Soil Moisture Sensor: A0 pin to Arduino analog pin A0, Soil Moisture Sensor GND pin to Arduino pin GND and Soil Moisture Sensor VCC pin to Arduino pin 5V.

We can now show the result in the blynk mobile or web application (Figure 25).

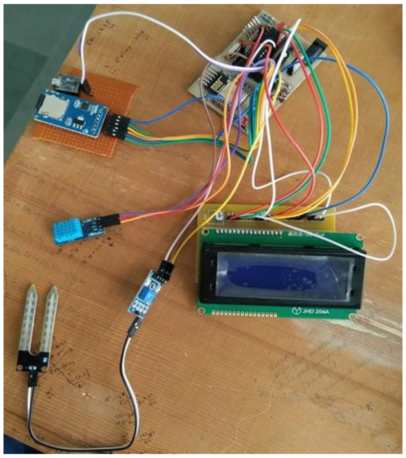

Fig. 23 Final combination of prototype, IoT board with Atmega 328P and node MCU ESP 8266, SD card module with SD card and 3.5mm audio jack, DHT 11, soil moisture sensor, LCD display unit (20x4)

Fig. 24 Showing the figure of the final prototype

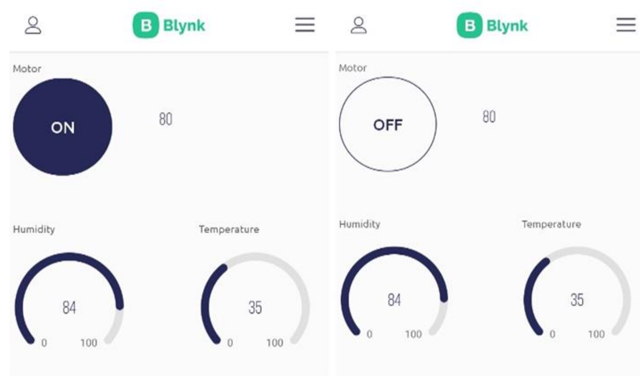

Fig. 25 Resulted in values or data collected by the soil moisture, temperature and humidity sensor (DHT11) and button to turn on/off the water pump (motor)

7. Conclusion

Here we concluded that talking plants may be used with little trees planted in offices based on the testing findings. It is doing successful real-time monitoring of plant health, including parameters of soil moisture percent, temperature and humidity. Temperature and moisture sensors for the soil can function effectively with mobile applications. Users may instruct a water pump to water plants through a smartphone application. Applications for mobile devices can display temperature, soil moisture value, and humidity value data in real time to improve the accuracy of the sensors that would display data on a mobile application as well as all the values that can be seen in the web application. The real-time monitoring of plant health has gained significant attention related to the indoor environment. As a result, it does well whenever the soil moisture value goes below/lower than 40%. It is said the statement, "I'm sad, please help me", and the water pump (motor) can be switched on using a mobile/web application, and whenever soil moisture percent goes above 80%, it says, "I'm happy now".

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