IOT Enabled Smart Drip Irrigation System Using Web/Android Applications

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Abstract— The water requirements for irrigation have been very demanding nowadays. There is a requirement for a wise irrigation system which will save a good amount of water. In the world, water and food are two of the most important resource, which makes agriculture crucial to mankind. With advancing technology growth in the agriculture sector, the internet-of-thing (IOT) technology provides a solution much simpler and faster for drip irrigation. Under this paper, an IOT enabled smart drip irrigation system is being developed where a system architecture is designed. A microcontroller along with a nodeMCU is used for sending the data in the cloud in the server. A web-based application is also developed so that the user can take appropriate action accordingly for drip irrigations. This web application accurately controls the water level by employing a soil moisture sensor and microcontroller system in the gardens. This is realized by integrating the sensors within the developed prototype to observe the soil moisture level, humidity, and temperature conditions where these data send through the micro-controller and nodeMCU for the requirement of water to the plants. Crop health can be monitored and controlled through mobile and desktop computers and provides a solution for smart farming, agricultural fields, Lawns, gardening, etc.

Keywords— IOT, wireless communication, Irrigation system, sensor networking, cloud platform, etc.

I. INTRODUCTION

The agriculture is the indubitably the biggest livelihood source in India. With a growing population, there are required for increasing the production rate of agriculture products. To sustain a better production rate, the quantity of spotless water in irrigation will always ascend. At present, according to the sources, the agriculture sector embraces 83% of the total water utilization in India [1,2]. Accidentally, the use of water is not a planned way therefore, it is wastage of the water. This illustrates that there is a critical need to develop systems that stop the wastage of water without putting pressure on the farmers. The health management of plant is the one of science steam for understanding and overcoming the succession of biotic and abiotic factors that set the boundary for plants to achieve the entire genetic perspective such as crops, ornamentals, timber trees, or other uses. Under this area, plant health monitoring plays a vital role in monitoring agriculture crop conditions [3-5]. The majority of the irrigation methods are manually operated and it takes a lot of time for a big land. Considering these aspects, some automated/semi-automated methods have also been applied for the irrigation of the land. These methods can provide the substitution of traditional agricultural methods. Some of the conventional methods of irrigation are used like drip irrigation, sprinkler and ditch irrigation, etc. Using the automated system, the problem of said irrigations can easily be controlled. During the automated system, internet-of-thing (IOT) plays a vital role in the agriculture industry where IOT is a shared network system for communication between different things and objects. These can communicate with each other within available the Internet connection. By using IOT, smart agriculture helps in the minimization of wastage of usages like time, labor, and resources which helps in increasing crop yield and productivity. In the proposed work, an IOT based smart system is being developed for monitoring the crop yielding using different sensors like soil moisture, humidity, and temperature. The sensor data are stored in a web server database using a cloud network system. Using a soil moisture sensor, the condition of the soil moisture can be checked. When any change in humidity and moisture of the soil will occur, these sensors update the changes and the signal will be passed to the microcontroller. The irrigation system will be controlled accordingly. This automated irrigation system integrated with a web application and user interface so that the user can access the data and monitors the system remotely on the mobile phone. The smart IOT irrigation system can be utilized the real-time data of any field. The main advantages of such IOT based drip irrigation system are to develop a low cost, reliable, and energy-efficient based IOT control system for drip irrigation.

The main objective of this paper is to design and develop a novel IOT enabled smart drip irrigation system to reduce the usage of excess water and electricity inefficient manner. To stop unused water and reduce the labor cost, a monitoring system is designed which will be controlled through mobile anywhere. The major contributions of this paper are focused on the following points.

- Development of an automated drip irrigation system to monitor the soil moisture conditions.
- Design an IOT based web application for controlling and monitoring of the plants.
- To communicate and store the data in the cloud for analytics.

- Visualizing the soil moisture, temperature, and humidity through mobile phone.

This paper is structured as follows: a past research survey on IOT based technology for smart drip irrigation is presented in section II. A design of IOT enabled drip Irrigation sensing, control, and monitoring system is proposed in section III. In section IV, the system architecture for IOT based drip irrigation is designed. A process flow of IOT enabled smart irrigation system is discussed in section V. A prototype is being developed and implemented as discussed in section VI. The conclusion is written in section VII.

II. Literature survey on IOT based technology for Agriculture applications

In the past, some of the researchers have carried out work on IoT related activities for the automated irrigation system. Kansara et al. [6] have focused on a review of some of the automated irrigation systems along with IOT whereas the traditional farm-land irrigation techniques along with manual intervention are also discussed. Bedekar et al. [7, 8] have focused on the development of hardware and its networking system along with software development for precision irrigation systems using IOT where the preliminary results revealed that this kind of system can be implemented and practiced. Siddagangaiah [9] has explored an IOT plant health monitoring system where this system can be verified the environmental parameters such as humidity, temperature, and light intensity, etc. This also recovers the soil moisture condition. All updated information is provided through Arduino UNO development boards to the Ubidots cloud platform. If there is any variation in the stored sensor data, an alert message will receive to the users via smartphone. Rajalakshmi et al. [10] have focused on IOT based system to monitor crop-field using sensors and the automation process of the irrigation system is also done. Kranthi Kumar et al. [11] have developed an automated irrigation system using wi-fi communication where IOT is used for home gardening and irrigation for farming lands. The system is developed using soil moisture and temperature sensors. The soil moisture sensor is fixed at the root of the plants. Sukriti et al. [12] have focused on reducing water wastage using a smart irrigation system to achieve optimal irrigation for continuously monitoring the water level. Agarkhed [13] has presented the IOT based Wireless Sensor Network (WSN) for irrigation system which is converting fast way as compared to the traditional agriculture whereas Rawal [14] has attempted on IOT based information system where the soil moisture sensing unit frequently keeps updating on a webpage by which the farmers can confirm about the water sprinklers on/off condition at particular given time. Nandhini et al. [15] have focused on an automated irrigation system using Arduino microcontroller for efficient water organization where the soil moisture, humidity, pH conditions are measured and these have displayed in the monitoring system. Shekhar et al. [16] have attempted an intelligent IOT based automated irrigation system for estimation of the water towards irrigating the soil where the devices interact between sensors and controllers and data are updated using IOT platform. Govardhan et al. [17] have developed a time-based system for automatic irrigation where data have been sent through GSM module which reduces water requirement and increases the productivity of plants. Khan et al. [18] have developed an automated drip irrigation system to optimize water usage for agricultural applications. The system has developed using a distributed wireless network system. Verma et al. [19] have described an efficient system of irrigation to minimize the consumption of water which permits through remote control devices for monitoring the sequencing of irrigation systems. Rafiq et al. [20] have attempted on IoT based automated irrigation system for agriculture applications where all data have been sent through Arduino process and it has noticed in an enrolled cell phone. Alves et al. et al. [21] have attempted on a digital-twin for the agricultural applications which is implemented by sensing a variation in the smart water management projects of Brazil. Further, we are proposing the IOT based smart irrigation sensing, control, and monitoring system for enhancing the productivity of plants. Alreshidi [22] has presented the reviews work on the development of smart, sustainable agriculture (SSA) and provides an IOT based architecture to develop an SSA platform. Upadhya et al. [23] have attempted on crop yield estimation of vegetable crops using a fuzzy logic control method where temperature, humidity, and moisture of soil are taken as input parameters and crisp value of yield is obtained using the fuzzy arithmetic method.

Based on the literature survey, it is found that the combined IOT enabled drip irrigation sensing, control, and monitoring system is not explored till now. Therefore, we are proposing a novel IOT based system architecture for drip irrigation which will be controlled through using web/android mobile phones. This will lead to the novelty of this paper.

III. Design of IoT enabled drip Irrigation Sensing, Control and Monitoring System

In agricultural fields, water management is a major issue due to the lack of water resources. To minimize the problem, the smart irrigation system is developed and a schematic diagram is shown in **Figure 1**. During the development of this system, the soil moisture, temperature, and humidity are integrated with the control system for monitoring and control the water. In this control system, the environmental parameters like soil moisture, temperature, and humidity will be observed where the operating the pump, a threshold value is set. As per the requirement of water, the pump will be automatically switched off/on. This will also intimate about the current water condition of the field and the information will also be sent in the URL of the web page of the internet and mobile phone. The major advantage of this system is that the user can observe the health of the crop and monitor the condition of the field at any time anywhere.

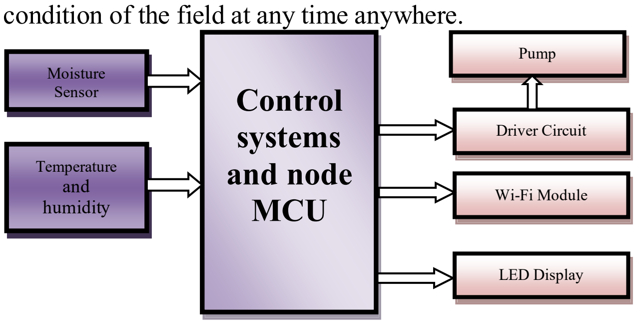

Figure 1. Layout of a control system for IOT based smart irrigation system

IV. Design of Architecture for IOT enabled Drip Irrigation System

The following components are used for developing the system architecture towards IOT enabled smart irrigation sensing, control, and monitoring system as below:

1. Soil moisture sensor (FC-28):
This sensor gives the quantity of the volumetric content of water when it is inside the soil and provides the moisture level as output. Input voltage for the sensor 5V and the analog output voltage varies within 0 to 4.2 V according to the moisture value. The sensor consists of four pins (VCC: for power, A0: analog output, D0: digital output, GND: ground) among which VCC, A0, and GND are used.

2. Humidity and temperature sensor (DHT11):
This sensor measures the atmospheric humidity and temperature values. The input voltage for this sensor is also 5V. This sensor also has four pins (VCC: For power, Data out: For sensor reading, the Third pin is not used, GND: Ground). The sensor is powered by the Arduino controller to VCC and GND and the sensor data reading is taken from the Data out pin.

3. Microcontroller module (Arduino YUN):
This he board of this microcontroller is on the ATmega32u4 and the Atheros AR9331 with Ethernet and WiFi support. The ATmega has a processing speed of 16 MHz. The controller board is operated at 5V DC. This board can be utilized for implementing the control mechanism as well as the data communication in the network.

4. NodeMCU ESP8266
NodeMCU ESP8266 wifi chip is an open-source platform for a hardware design that explores the interfacing and functionality capability with ESP8266.

5. Double Channel Relay
Double channel relays switches are used for opening and closing the motors on command. There are three contactors: open (NO), closed (NC) and common (COM). At the ON input condition, the COM is connected to NC.

6. DC 9V Submerged Water Pump
A submerged pump is used for properly providing the water a DC motor device that moves fluids.

7. Router
A router is a device that can be used for networking the system. The router can operate the forwarding of the data in the packets between computer networks. Routers execute the traffic functions using internet sources so that the Internet of Things can be connected.

8. IOT Cloud
IOT or Internet of Every Thing (IOE) is a Cloud platform that is used to store and process IOT or IOE data. The IOT or IOE Cloud is described as a "massively scalable real-time event processing engine". Thing speaks IOT cloud platform is used during the development of this system.

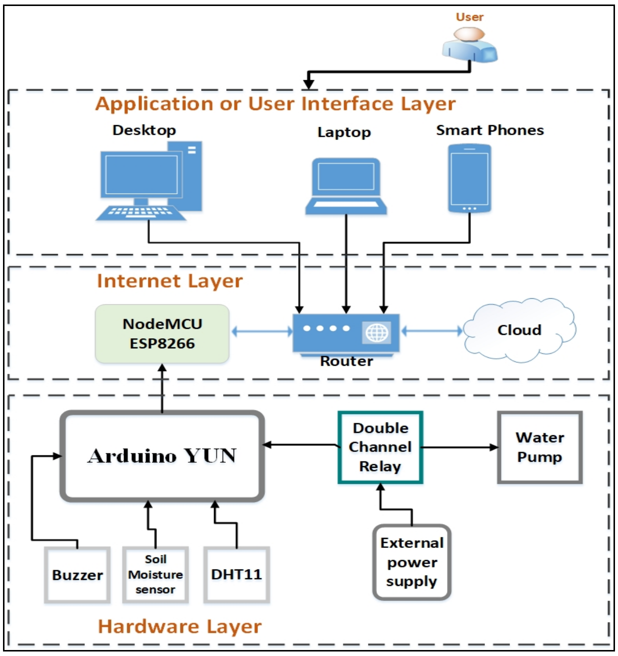

Figure 2. Overall Block diagram for I enabled smart irrigation

9. Android Studio
Android Studio is known as an official integrated development environment (IDE) for the development of the android application. This application is based on the IntelliJ IDEA where the Java integrated development environment is used for the development of the software. The code is editable where a developer tool is also available.

To design system architecture, the three layers are designed as shown in **Figure 2.** These are the sensing layer, internet layer, and user layer. In the first sensing layer, all sensors (soil moisture, humidity, and temperate sensor) are connected to a microcontroller (Module: Arduino Yun) through power supply which provides data communications between them. A submerged pump is also used for providing water controlling of the system. The microcontroller module is connected to a double channel relay for proper activation.

This layer is connected to the internet layer through NodeMCU ESP8266 for providing communication between the open-source platform and hardware system. A router is also used for wireless communications. Further, NodeMCU ESP8266 has established communication with the Android Application via IOT cloud. This kind of application system can be utilized for monitoring and the controlling system where automation of agricultural parameters like temperature and soil moisture needs to be monitored and controlled by the system. A web-based system is also developed for monitoring and control of smart drip irrigation systems anywhere.

V. Process Flow of IOT enabled Smart Irrigation System

The schematic layout of the control diagram is shown in **Figure 3**. In the Arduino YUN microcontroller, the command from PC is sent to for reading the sensor values. Arduino interprets the instruction from the PC and activates/deactivates the sensors. The acquired values from different sensors are then transmitted to the PC via the

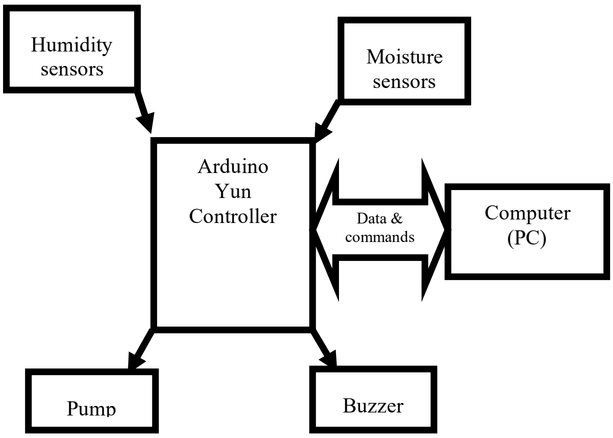

Figure 3. Layout for controlling different sensors using microcontroller

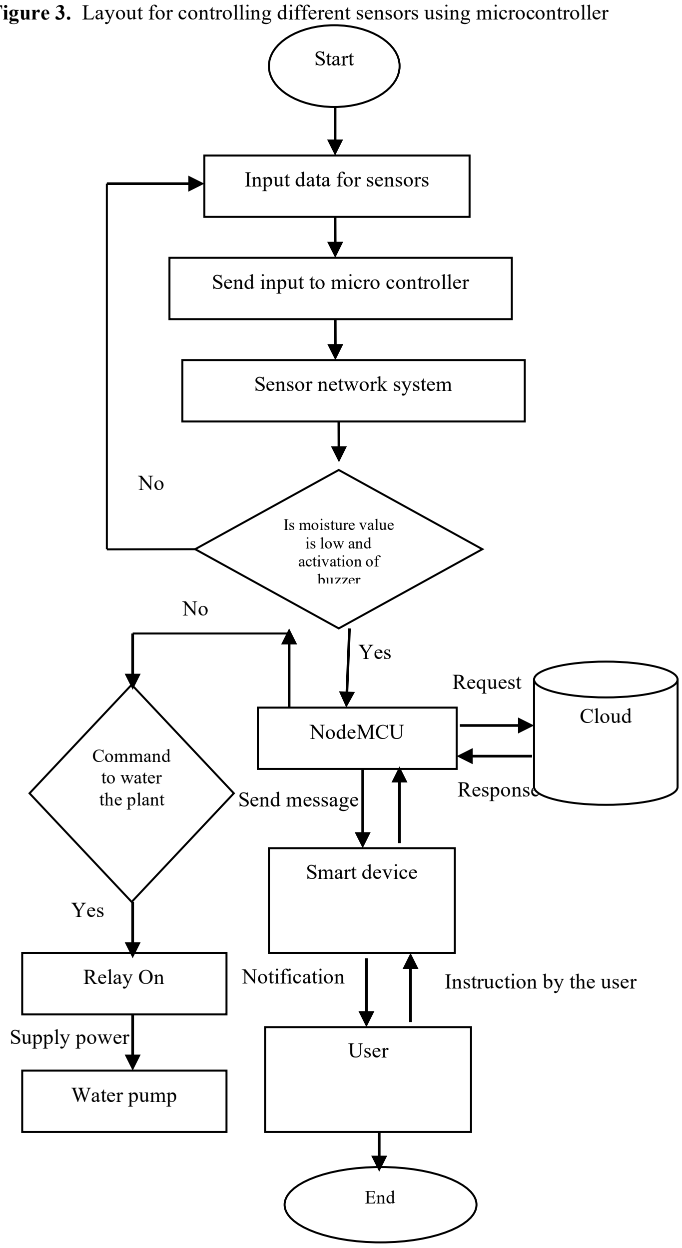

Figure 4. Process flow chart for controlling the pump

configured network. The pump and buzzers are also activated/deactivated by the Arduino according to the requirements. The flowchart is shown in **Figure 4** which presents the operation of the smart irrigation system. At first, Arduino based irrigation system and PC based monitoring system are configured in the same network for data and command exchange. The process needs some initial time for configuration and connection establishment purposes. After the startup processes, the PC side monitoring process is initiated and a check is performed for any critical issues. On the identification of any critical issue, the buzzer is activated and kept in the same state until the issue is resolved. Further, the check is performed if the issue is related to soil humidity or not. If watering of the plant is needed then the pump is activated and kept at the same state until the moisture level reaches a safe zone. Finally, the last check is performed whether the user wants to terminate the process or not if no termination is intended then the current set of sensor data and process status is saved in the PC side and the process is repeated for the continuous checking of any kind of issue. This is connected through NodeMCU and sends the message to the smart device and provides the user notifications through mobile. As per instruction the by user, it is sent to the smart device again. The data will be uploaded in the cloud through nodeMCU. The data can be monitored through the webpage in the computer and mobile anywhere by providing user login and password. The pump can also be controlled through mobile and update the information accordingly.

VI. Results and Discussions

To develop the smart irrigation system, the testing setup is being developed as shown in **Figure 5**. In each plant, the different modules like sensors, Arduino, nodeMCU web-server, cloud, etc are connected to the microcontroller. The soil moisture sensor, temperature, humidity sensor, and one buzzer are used. These are connected with the Arduino which obtains the sense data from the sensor, processes it, and sends the data to the cloud via Web-server which we are going to create using the node MCU. A sensor data is sent through the web-server process and sends it to the cloud and using the third-party cloud. We are visualizing the sensors' data inside the cloud, which will be visible to the owner of the system or the authorized persons. A submerged water pump is installed in the tank which will work according to the soil sensor, in programming the threshold is set. If the threshold value is low then the water pump will automatically on and when it fulfills the threshold value it will turn off the water pump. A relay is used which is connected to a microcontroller for operation. It will control the voltage-current flow (electric) as well as on or off the pump according to the program.

Figure 5. Development of IOT enabled drip irrigation system

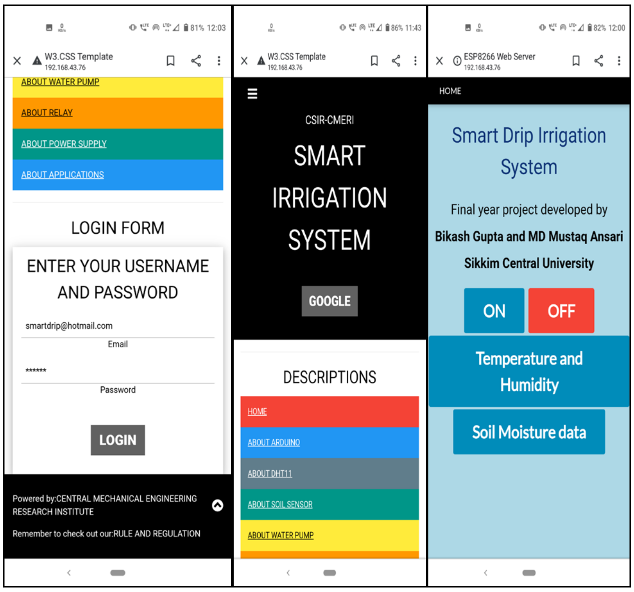

Figure 6. Development of Android app

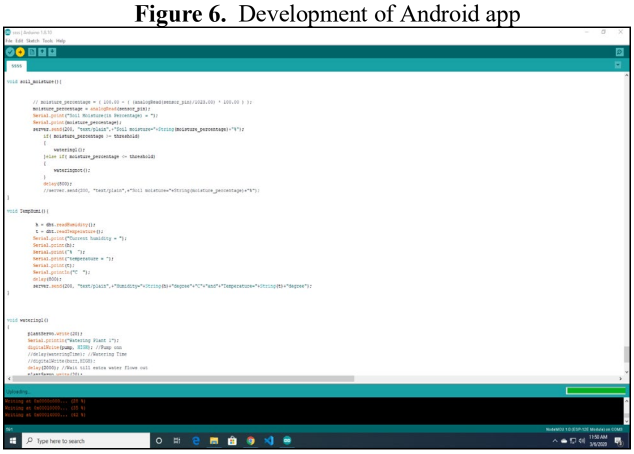

Figure 7. Description of the codes used for developing android applications.

The data is sent through NodeMCU in Web-server. A login page is also designed as shown in **Figure 6**. At first, the login page will be opened i.e. home page, after the correct credential only the owner or user will able the see the sensor data via the cloud, control the system, and manage the same through gateways. For the same purpose, we have developed an Android app so the user may able to control, visualize, and manage the entire system. For the development of the Android app, a web page is being developed in the Thinkspeak™ platform as shown in **Figure 6**. The ThingSpeak™ is an IoT analytics platform service that provides the services to allow the aggregate, visualize, and analyze the live data in a cloud environment and send a message and alerts using web service. The description of the code in Ardunio is shown in **Figure 7**. Therefore, during development, it is used which store data in a faster manner and the webpage opens within a few seconds through the gateway. To measure the soil moisture level for each plant, the experimental data have collected as given in **Table 1** when soil moisture is inserted in over irrigated soil. These data are collected in 2 sec up to 50 seconds. These are plotted in **Figure 8**. The threshold value of the moisture sensor is set in 1024. If the moisture level of the plant is below 40%, the water pump will start automatically to maintain the soil moisture level of the plant. If the moisture

Table 1. Data of soil moisture values for the sensor in the plant

Time (sec)	Trial 1	Trial 2	Trial 3
2	1024	1024	1024
4	1024	1024	1024
6	1024	1024	1024
8	1024	1024	1024
10	1024	1024	1024
12	1024	1024	1024
14	1024	1024	1024
16	1024	1024	1024
18	1024	1024	1024
20	1024	1024	1024
22	718	513	409
24	518	514	416
26	543	517	443
28	571	511	473
30	578	526	476
32	591	528	493
34	620	590	517
36	639	611	533
38	782	622	577
40	712	642	592
42	736	659	637
44	728	678	666
46	742	697	681
48	876	752	688
50	867	872	699

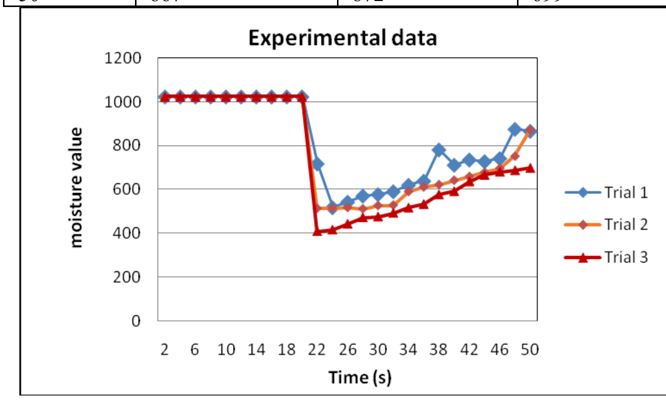

Figure 8. Experimental data of the moisture value of the plant

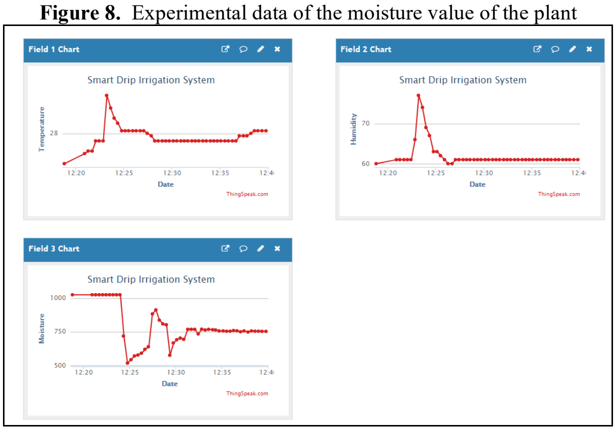

Figure 9. Snapshot of IOT cloud platform in mobile phone

level of the plant is above 40% of any plant, the pump will stop automatically. This data will also be updated in user mobile phone through webpage using IOT cloud platform and the plant condition is also visualized accordingly as shown in **Figure 9**. To observe the humidity and temperature of surroundings, the humidity and temperature sensors are also incorporated in the system. All plants are installed in an open environment. Through sensors reading, it is found that the temperature is ranging from 26.5-29°C and the average humidity is 63 %. Hence, this IOT based system provides help in reducing crop damage due to excessive moisture level by providing data of soil moisture using sensors. This will help to avoid over/under irrigation of soil. By developing this system, it is studied that this kind of development in farming for a variety of land, bigger nurseries, or open gardens can enhance productivity using automation and IOT technology in modern days. By this means, the utilization of efficiently water resources for irrigation can be smartly handled which are major problems in the existing/conventional/manual and unwieldy procedure of irrigation.

VI. CONCLUSION

In this paper, a novel IOT enabled automatic drip irrigation system using web application is being developed where a system architecture is also designed for monitoring and controlling of the soil sensor, temperature, humidity. These are interfaced with microcontroller and nodeMCU for wireless communications with the cloud network system. In this cloud network system, the stored data can be remotely accessed through a web-based application. By operating a submerged pump, the plant/crop health can be improved and the plant/crop health can be monitored anywhere. This provides an appropriate solution for accessing the supply of water sources for agricultural applications. This IOT enabled irrigation method allows for farming to reduce the shortage in that way the improvement can be done to hold water for suitable applications. By creating the testing setup, it is demonstrated that IOT enabled drip irrigation system could be a good substitute for the assorted area where mainly harvest needs for the involvement of least amount preservation. This IOT enabled drip irrigation system can be applied in a variety of land, bigger nurseries or open gardens, etc. Implementing this kind of system will permit users like farmers, gardeners to observe and nurture the yield of crops, and improve overall production. The sensor network will be decided upon land capacity. Hence, IOT enabled a smart irrigation system is a promising approach in precision farming and agricultural applications.

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