Smart Irrigation Using Internet of Things

Aditya Vishnu Garg
Trinity College Dublin
School of Computer Science & Statistics
ADGARG@TCD.IE

Ashish Kannur
Trinity College Dublin
School of Computer Science & Statistics
KANNURA@TCD.IE

Himanshu Gupta
Trinity College Dublin
School of Computer Science & Statistics
GUPTAH@TCD.IE

Mayur Sadashiv Mahajan
Trinity College Dublin
School of Computer Science & Statistics
MMAHAJAN@TCD.IE

Shubham Dhupar
Trinity College Dublin
School of Computer Science & Statistics
DHUPARS@TCD.IE

Vivek Kumar
Trinity College Dublin
School of Computer Science & Statisticss
VIKUMAR@TCD.IE

***Abstract*—Agriculture has been the most important practice and livelihood provider in many countries but the traditional methods used are not much efficient as they result in a lot of water wastage and formation of fungus due to over moisture in soil. This paper proposes an effective and efficient automated irrigation system using ESP32 micro-controller. The goal is to help farmers in irrigating their land in a more convenient way. The system includes programmed sensors such as soil moisture, humidity and rain sensor which send data to ESP32 micro-controller. ESP32 transmits the data to AWS cloud using Message Queue Telemetry Transport protocol where it is processed and result is sent back to ESP32 notifying start/stop of the motor. The data gathered by sensors can be viewed in Amazon Web Services (AWS) and websites by users to keep a track. The system also includes manual operation of motors in case of connectivity failure where users can control the water pump through the website or direct switch. In this way, a secure, conservative and automated system is developed solving agricultural irrigation problems.**

***Index Terms*—Internet of Things, Agriculture, Irrigation**

I. INTRODUCTION

As the population is rising exponentially, there is an immediate need for agricultural production to cope with the demands. In order to withstand this demand, greater production is required which in case gives rise to the requirement of fresh water in irrigation as seen in figure-1. The unplanned/ineffective use of water may result in loss or wastage. In the current situation, one of the world's biggest issues is water conservation and proper utilization. This pressure on the water distribution system is increasing and gives rise to sustainability water management in irrigation. This suggests an immediate need for an effective system that will prevent water wastage and would be smart enough to handle the water conservation too without imposing pressure on farmers.

It is seen that from the past few years, users/farmers started using computers and software systems to organize data and keep records of transactions. So, we can say that the Internet era is not new to them as they are quite familiar with it. In this project we are trying to blend Internet of Things technology with agriculture and come up with an idea of a Smart Irrigation System.

Smart irrigation is an innovative approach toward the irrigation system and every year many researchers contribute toward its development and new ideas. Saikia et al. (2016) proposed a system for Smart Irrigation in their paper. They mentioned that the current irrigation method is mostly regulated physically by farmers/users where they irrigate the land at regular intervals which some time may lead to water loss and even in less rainfall regions it is challenging. They came up with an idea of an irrigation system which will control and monitor water requirements in soil and make prudent use of water. This system can be applied to large as well as small areas [1]. Padalalu et al. (2017) proposed Smart Water Dripping System for Agriculture. Their model controls and monitors irrigation time and stores sensors data for analysis. The system included micro-controller which checks and operate likewise [2]. The main idea behind our project Smart Irrigation System is to have a system that would work automatically without human intervention and maintain the soil moisture by systematically watering the plants, when required. It should be smart enough to know when to start the motor but also to when to stop

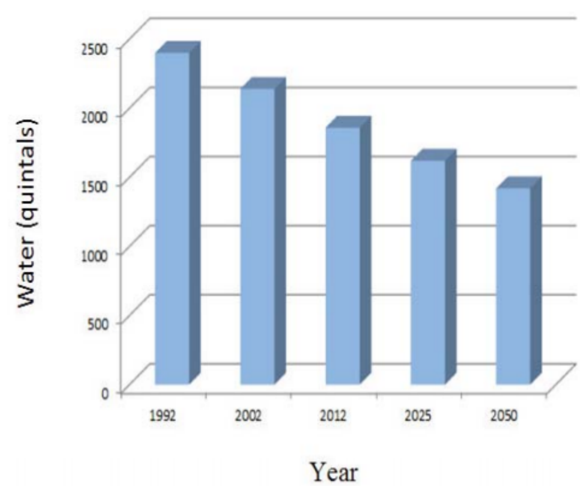

Fig. 1. Year Wise Water Crisis in Irrigation

it if it is raining, to preserve water and power consumption. This system will benefit end user in many ways from water conservation to increased production. It will reduce man effort required for carryout task, prevent over moisture in soil which results in fungal growth and reduce power consumption by carryout irrigation when required.

The rest of the paper is organized as follows: Section II gives an overview of system architecture and its components. Section III deals with methodology and implementation of smart irrigation system. Section IV, presents the future scope of this system followed by conclusion.

II. Architecture

The planned automatic irrigation and control network consists of the ESP32S, water pump, soil moisture sensor, and rain sensors.

Figure 1 demonstrates the technical layout of the project. The ESP32S is connected to the Amazon Web Service (AWS) cloud using MQ Telemetry Transport (MQTT) secure protocol.

A. Components Description

- ESP32S
  The Espressif® ESP32S is a low power micro-controller which is ideal for IoT solutions. It has built in WiFi functionality using which we transmit our sensor data to the cloud and then subsequently receive instruction from the cloud [3].
- Soil Moisture Sensor
  Soil moisture sensor is used to monitor and evaluate the moisture content in the soil of the agriculture field. This sensor has two copper electrodes which are inserted inside the soil, and the conductivity between these electrodes is used to calculate the moisture content [4]
- Water Sensor
  Water sensor is used to detect the water level in the soil of the field by measuring the electrical conductivity of the water. The water levels are useful to check if the water levels are sufficient for the yield or not [5].
- DHT11 Temperature Sensor
  DHT11 is a temperature and humidity sensor that calculates relative humidity by measuring the electrical resistance between two electrodes. The humidity is useful for the photosynthesis process of plants and if the water level is too high, plants will not be able to evaporate the water, so it is important to monitor humidity levels of the agriculture yield [6].
- AWS
  AWS is a cloud computing platform that is used for sending, receiving and managing the data sent by the ESP32S. AWS is also being used for displaying the real-time data on the dashboard. The dashboard is integrated with node-red via secure MQTT connection [7].
- Motor
  Motor is used to release water into the yield. The motor works on the signal of the micro-controller and helps releasing or controlling the water [8].

III. Method

The smart irrigation system involves three major components as Sensors, ESP32S and AWS. There are three sensors in the system that sense the data and send the data to the cloud via the WiFi module of ESP32S and then based on certain conditions that enable the motor to work accordingly. The system also has a dashboard that shows real-time data that sensors have sent.

The three sensors used are the DHT11 temperature sensor that senses the humidity and temperature, the water sensor that senses the water level and the soil moisture sensor that detects the moisture. The data of these five readings is sent to the AWS cloud using the WiFi module of ESP32S. The data that is being sent to the cloud is in JSON format and it is secured with the use of MQTT protocol.

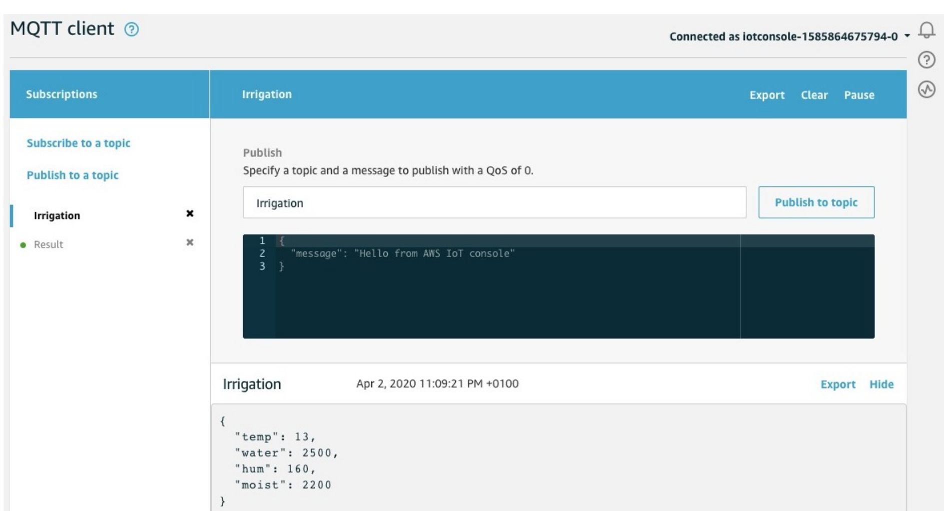

Fig. 2. AWS Receiving Data Using MQTT

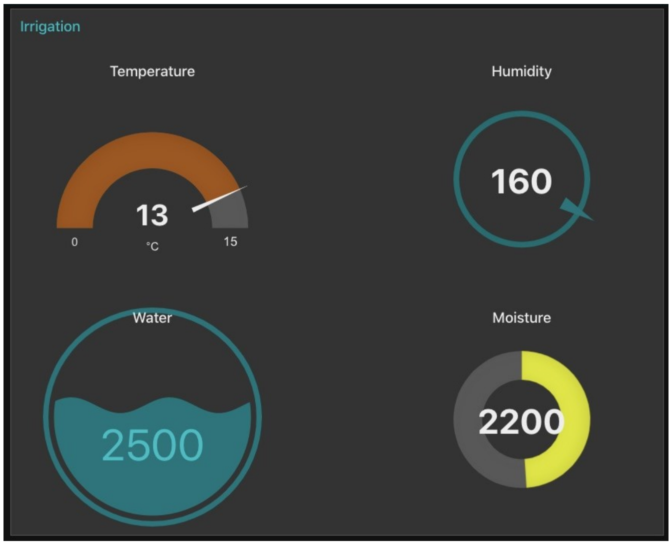

Fig. 3. Cloud Dashboard Displaying the Statistics from Sensors

On AWS IOT core, an IOT thing named “Irrigation” is created and that acts as a subscriber to the data sent by ESP32S. The code on the Arduino IDE works as a publisher to this thing and sends data for all five sensors. The MQTT protocol makes use of digital certificates that provide end-to-end security to this data transfer between micro-controller and cloud.

Once the data is available on the cloud, the system uses a third-party platform node-red, to generate a real-time dashboard. The dashboard displays all the information about the yield such as current temperature, humidity, moisture and water level. The weather API is also integrated with AWS using OpenWeatherMap[9] that enables the system to display the weather forecast. This forecasting of weather data can be useful to stop wastage of water.

Based on certain conditions for each of the data, the node-red sends a binary output to AWS that can be useful to turn the water supply to yields using the motor. One of the conditions that is based on the weather forecast is turning the motor on only when the chances of rain in the next few hours are less than 60%. All the data transfer between node-red and AWS is based on secure MQTT protocol. Another topic is created on AWS and node-red named result. This topic is first published from AWS to send the data for the dashboard and then acts as a subscriber that takes binary output from node-red.

The binary output is then sent by the AWS using the Irrigation topic working as a publisher. ESP32S receives the binary output and based on the output, it switches the motor on or off. This system automates the process of the agricultural cycle and reduces human effort. Also, it can help in reducing the wastage of resources.

IV. Future Work

Due to COVID-19, all of the group members were segregated and it was difficult to work on the project as different hardware components were being carried by various group members. It is because of this reason, we were unable to connect water pump connection with our servo motor, as the parts were in different countries. Subsequently, an option to include an override option in the dashboard couldn’t be completed and would be part of the next version of the product.

In the future, a variety of enhancements may be applied to this framework, which involves giving the user more control by adding options like scheduling of a duty cycle wherein water pumps can be switched off during an off-season or field maintenance. Renewable sources of energy like Solar Power would be also be added in near term, to make every node independent and to decrease the chances of entire network going down.

Further, edge computing can be added, so that not all nodes need to be connected to the internet, so that for every group of non-internet nodes, there is at least 1 dedicated internet-connected node in the vicinity.

One thing that needs to be addressed is to push this product to the next level and make it ready for the consumer level, by further improving the user interface of the dashboard and making the applications for smartphones.

V. Conclusion

In this project work, we have successfully built a system that automates the traditional irrigation system which is usually done manually by the farmers. Our smart IoT system does it by measuring the soil moisture level, the humidity level, and then combines that information with the weather forecast data on the cloud, to switch the water pump on and off in a farm field.

References

[1] P. Singh and S. Saikia, ”Arduino-based smart irrigation using water flow sensor, soil moisture sensor, temperature sensor and ESP8266 WiFi module,” 2016 IEEE Region 10 Humanitarian Technology Conference (R10-HTC), Agra, 2016, pp. 1-4.

[2] P. Padalalu, S. Mahajan, K. Dabir, S. Mitkar and D. Javale, ”Smart water dripping system for agriculture/farming,” 2017 2nd International Conference for Convergence in Technology (I2CT), Mumbai, 2017, pp. 659-662.

[3] ”ESP32 Overview Espressif Systems”, Espressif.com. [Online]. Available: https://www.espressif.com/en/products/hardware/esp32/overview.

[4] ”Ks0049 Keyestudio Soil Humidity Sensor”, Wiki.Keyestudio.com. [Online]. Available: https://wiki.keyestudio.com.

[5] ”Ks0048 keyestudio Water Sensor”, Wiki.keyestudio.com, 2020. [Online]. Available: https://wiki.keyestudio.com.

[6] ”Ks0034 Keyestudio DHT11 Temperature and Humidity Sensor”, Wiki.keyestudio.com, 2020. [Online]. Available: https://wiki.keyestudio.com.

[7] ”Ks0209 keyestudio 9G Servo Motor Blue 90”, Wiki.keyestudio.com. [Online]. Available: https://wiki.keyestudio.com.

[8] ”Amazon Web Services (AWS) - Cloud Computing Services”, Amazon Web Services, Inc.. [Online]. Available: https://aws.amazon.com/.

[9] ”Weather API - OpenWeatherMap”, Openweathermap.org. [Online]. Available: https://openweathermap.org/api.