Internet of Things(IOT) based Smart Garden System using Soil Moisture Sensor

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***Abstract*—The system proposed in this paper is an advanced solution for nurturing the garden and make the things possible staying anywhere in the world. The technology behind this Internet of Things(IOT), which is an advanced and efficient solution for connecting the things to the internet and to connect the entire world of things in a network. Which is possible by using ESP8266-12E [1]with the Arduino IDE and interfacing with a water level monitor sensor and water pump motor/sprinkler using MQTT server the data is uploaded to Iot server. The DHCP server is showing data if the plant need water or not. This project was developed to produce a prototype product of a web based smart garden system that allows the user to nurturing his or her garden while he will not in home. The enhancement from the existing system is that this prototype system allows the data to be monitored anytime and anywhere from the internet. This project is divided into two parts that involved with the hardware and software. The hardware part involves building the soil moisture sensor board and software part involves written programs based on programming language. The programs then are uploaded into the ESP8266-12E [1]. This protype of a web based smart gardening has met almost all the objectives derived and planned. The project is considered successful and ready to be launched in the real system implementation.**

I. Introduction

Nowadays, the government promotes the policy to drive Internet of things (IoT) through smart device and system development for every sector of industry and business in everyday life, especially to improve the agriculture sector. In this project based on arduino and IOT is an Network of physical device. Gardening is the need of most of the Bangladeshi livelihood and it is one of the main sources of livelihood. A major quantity of water is used for irrigation system has 85% of available fresh water resource are used for yielding crops. An automatic plant watering systems not only helps gardens it is also used in agriculture. Many people plication to visualize the data from Dynamo database and to allow users to switch on and off the water pump.

demand increasingly to crop own organic homegrown plants for health and safety. However, some of them do not have time to take care the plants. Therefore, IoT Backyard is developed for monitoring and controlling water for soil-based plant. Users can setup plant’s profile via the IoT Backyard mobile application.

II. Literature Review

A. Related Work

M. S. Gavali et. al. [2] proposed an automated irrigation system to ensure proper use of water. The microcontroller is based on PIC16F877A equipped with an RTC DS1307, a ZigBee radio modem and a GSM module. It receives data from sensors of YL-69 for soil-moisture and DS18B20 for temperature sensor via ZigBee and shows these data on LCD display. They used the temperature and soil-moisture thresholds to switch on and off water pump. Users could monitor the values of sensors via Android application.

H. Gupta et. al. [3] deployed IoT for an automated precision farming system based on Arduino UNO attached with the sensors of pH and YL-69 soil moisture. The IoT server receives these two sensors data and forwarded them as a message to the farmers. The farmers can set the maximum and minimum threshold values to water the plants. If the soil moisture goes below the minimum threshold, the system will the motor to start the irrigation system.

H. Kuruva et. al. [4] applied Dynamo database through AWS IoT platform for remote plant watering and monito-ring system. They deployed Arduino UNO to read sensors of the water level and soil moisture and to forward the sensor data to Raspberry Pi running a nodejs application with the Johnny-Fibe library and AWS IoT SDK for javascript in order to communicate to AWS. The Raspberry Pi is also used for showing sensor data on LCD screen and controlling the water pump motor. Furthermore, they designed the web app.

For our project, IoT Backyard system is designed based on Arduino UNO and NodeMCU V3 and applies water level monitor and temperature sensors similar to the related work. But we deploy the MQTT server to save the real-time soil moisture and temperature values for each plant. Therefore, our system can support watering control for multiple plants. Moreover, The overall investment cost of this project is applicable.

III. Proposed Work

The proposed model includes a system that takes data from the environment and saves information to calculate the amount of water need for irrigation. The information is obtained through sensors connected to an Arduino One module. This information is sent to a cloud database through web services. In a pre-established amount of time, the system in the cloud calculates weather a crop needs water, if it is needed, the system sends a command to the Arduino module to open the valve for a period of time.

System Architecture

A. Microcontroller system

We deploy 2 microcontrollers: Arduino UNO and NodeMCU V3. Arduino UNO is equipped with the sensors of soil moisture (YL-69). The Arduino [5] UNO is attached to NodeMCU V3 via RX/TX interface in order to send data from these sensors to NodeMCU V3. NodeMCU V3 has a Wi-Fi interface to connect an access point coupling with the Internet to forward data from sensors the Cayenne system as well as to receive the watering thresholds from the sensor and forward them to Arduino UNO.

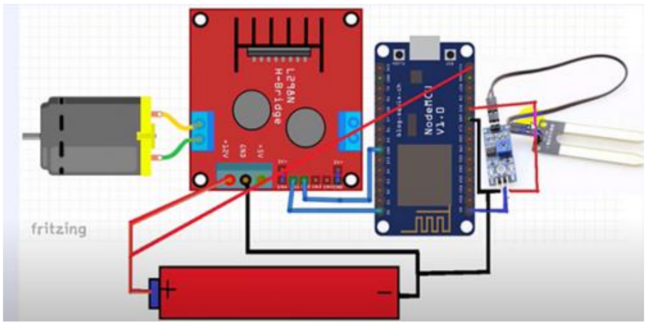

Figure 1: System Architecture of IOT Backyard.

i)Data acquisition:
For data acquisition, sensors should be used such as: soil moisture sensor, rain sensors, ambient humidity sensors, temperature among others. Each of these sensors are configured with different threshold values depending on the type of crop. Each sensor is sensing and acquiring data in intervals of time and these will be sent through Wi-Fi modules for their respective processing.

ii) Data Monitoring:A supervisor system needs to manage and monitoring the information gathered by the sensors (temperature, rainfall, moisture), settled sensors, crops and their cycles. A Graphical User Interface displays the information stored into the database. The monitoring shows statistics of water consumption about crops related to date and sections. Finally, web services are used to request all the data, this services are published on Internet to public access.

iii) Communication:
Communication is based on the cloud and each Arduino uses an ESP8266 Wi-Fi Module to communicate the solution to a database [9]. However, the database is not directly connected, because it is not secure; instead of direct connection it uses a Web Service (WS), and the WS inserts the sensors data into the database. The Wi-Fi module sends two fields: 1) an identification number (ID) and 2) the value of the sensor; the ID is generated by using the IP address of the Wi-Fi module and a unique number for each sensor type. This value is useful because it knows the origin of the information. While data are processing, the information is interpreted to know whether a crop needs water; when irrigation is necessary a WS is updated. In the irrigation system, the electronic valve is controlled by an Arduino and it is connected to a Wi-Fi module. In this case, it cannot be send an order from the cloud to the Wi-Fi Module, because it doesn’t have a public IP and it cannot be identified from the cloud. Like a solution the Wi-Fi module is constantly querying the web service. The valve is actioned when the WS is updated with a power-on time. Each Wi-Fi module has a static IP and connects to a gateway that allows the access to Internet. The visualization of the data is implemented with the database information to monitor the data. In the case study a web application has been implemented, however there can be used other ways to visualize the data.

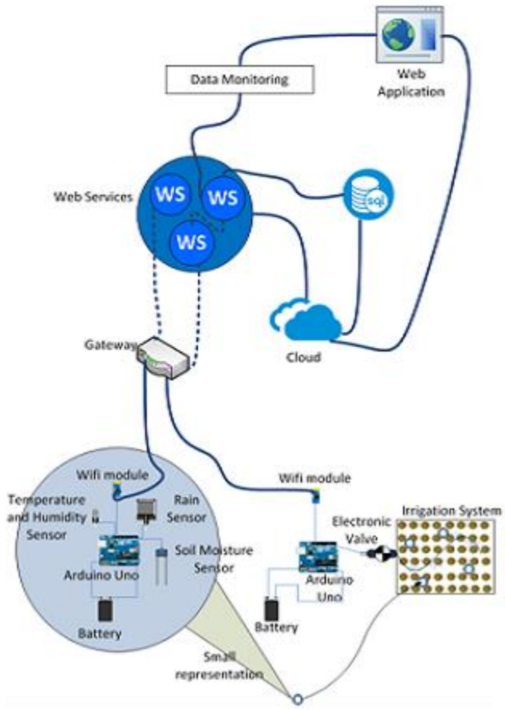

Figure 2: Architecture of the solution.

iv) Data processing:
Three integer values are received, as sensor data: Soil moisture, temperature and rainfall. These data represent information that will allow the making of decisions about the crop. If the soil moisture is lower than the crop needs, the valve will open. In the case of sprinkler watering, the temperature will allow watering or not. When it rains, watering will not be allowed. The values emitted by the sensors allow to open the valve or do not take any action.

v) Storage:
To maintain information about the types of crops, sensors and statistical data a database is needed. Using the structure, it is possible to save information about the crops, their cycles, order in which each irrigation has to be done. In addition, the information is saved on the sections being monitored and the sensors associated with each section. The entity "IrrigationTypeCropCycle" allows you to relate the type of irrigation to be applied to each crop for each cycle and the required amount of liquid to be supplied.

IV. EXPERIMENTS

We need a 12v battery for this project. Firstly, connect the battery with the NODE MCU wifi module. Then make a common ground for the battery [5]. Though, moisture sensor generate analog data, connect the wire to the Node Mcu A0 port. Connect another wire to the gound and other to the 3.3v port. Motor driver need 1 input pin to run motor. So, connect motor driver in1 pin to NODE MCU D0 port or 16 pin and another port connect to the ground. Connect motor driver to the 12v battery. Connect motor to the motor driver output pin. Then, we are done with the circuit connection.

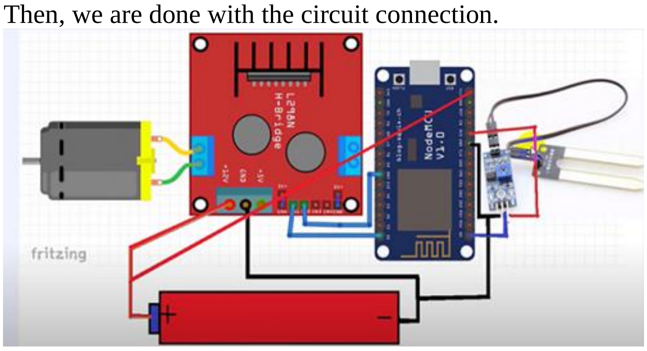

Figure 3: System Architecture.

Types of irrigation for cycles in the crop:
In the case of the strawberry, two types of irrigation should be implemented: 1) drip irrigation and 2) sprinkler irrigation, they are used according to the stage in which the crop is found.

a. **Sprinkler irrigation:** In the transplant phase, sprinkler irrigation is necessary. This is because this method provides a humid environment suitable for vegetative development, ensuring rooting of the plants after transplantation.

Figure 4: Sprinkler

b. **Drip irrigation:** Once the plants developed their roots, the drip irrigation stage begins. Irrigation tape is commonly used with drippers inserted at 15 - 20 cm and an average flow rate of 5 liters / h per linear meter.

Figure 5: Drip Irrigation

V. ANALYSIS AND RESULTS

Water Amount and Watering Time Compute:
One of the main milestones in the project is to perform an efficient calculation of the amount of water that will be supplied in the crops [6]. Each crop has its own cycles and each cycle needs a different amount of water. Whether to perform a sprinkler or drip watering, you need to open a valve that emits a certain amount of water, so we must determine the flow rate of the valve. If the flow rate of a valve is not known, the following technique can be used:

• Obtain a container with a specific measurement, i.e 1 liter = 1000 cubic centimeters.
• Connect the valve and measure the filling time.
• We use the following formula: $Q = v / t$, where Q is the flow rate (cm3 / seconds), v is the water volume (cm3) and t the time (seconds).

With the calculated flow, we proceed to give the intervals of time between watering. The month of the system is taken, the number of days of the month is multiplied by 24 hours, then the hours of the month. The number of hours of the month are divided for the number of monthly watering and a period of time is programmed between watering.

The number of square meters occupied by the section of the crop is multiplied by the number of liters of water per square meter in the standards, this value is multiplied by 1000 and get a value in cm3 . With these data, it is possible determine the time in which the valve will remain open. Now we calculate [7] the rate of flow :

$$t=v/Q.$$

The system sets up a time interval between watering. A signal is generated, which opens the valve for the calculated time and closes until the next signal. This system provides the crop the required amount of water. Given the environmental conditions, watering cannot be established as previously proposed. Exceptions should be made with the different environmental phenomena. For this, we use three sensors that provide the following data: soil moisture, temperature and rainfall.

The soil moisture sensor provides integer values between 0 and 1024. 0 is 100% humidity and 1024 represents 0% moisture in the soil. Tomattos should have 60% moisture in the soil, then, if the sensor value is less than 410, the soil has humidity greater than 60%, therefore, and it cannot be watered. If the value of the sensor is greater than 410, then it is waiting for the signal.

The temperature sensor provides us with integer values between 0°C and 50 °C. If the temperature is less than 26°C, watering is allowed. Otherwise, sprinkler irrigation can burn leaves when water evaporates. The system waits for the temperature to go down. Drip watering does not apply to this restriction. The rain sensor provides integer values between 0 and 1024, where values less than 500 indicate that it is raining, so watering cannot be allowed. If greater than watering is allowed.

Web application and data visualization:

A web application has been developed to display the data to the admin and final user. In the Graphical User Interface (GUI) the information from the database is shown. The administrator user can manage all data related to sensors (i.e., the crops in each section, configurations about a crop). The end user uses this application to request information about their crops. Statistical graphs are presented to analyze water saving, sensor data capture based on dates in the preconfigured crop sections. It was implemented in cisco packet tracer [8]. The web application was released by CISCO on may 12^{th},2017. However, it could be developed by using other technologies at the server side (i.e., processing, storage and monitoring web services).

VI. CONCLUSIONS AND FURTHER WORK

The deployed system presented in this document accomplishes the objective of taking data from different sensors and calculating irrigation needs for a given type of crop. Communication between the Arduino module and the cloud environment fulfilled the requirements. However, improvements can be done in order to reduce the amount of water that is wasted. This solution is scalable, which means that it can be used for different types of cloud services and can be used with many other sensors with other purposes.

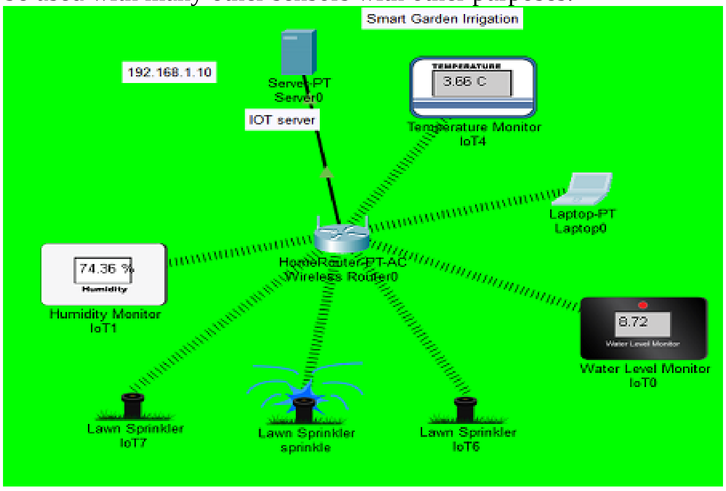

Figure 6: Web application and data visualization

So that in the future other types of sensors could be integrated to monitor plant growth, amount of fertilizer used, harvest time, etc. The system is expected to be integrated with other types of irrigation and multiple electronic valves, and is necessary to know more information of the crop to the irrigation system works efficiently. In addition, other types of valves could be used to accurately regulate the pressure and amount of water that is sent to the crop. It is also expected that the system can have several applications and can be used in parks, greenhouses, gardens, etc. Warning systems can be incorporated into the project in case of floods, fires or the poor condition of the crop. In addition, disaster response scenarios can be created by incorporating systems that drain water, fire systems, etc.

VII. ACKNOWLEDGEMENT

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VIII. REFERENCES

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