A Novel Approach to IoT Based Plant Health Monitoring System

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Abstract - *Plant health management is the science and practice of understanding and overcoming the succession of biotic and abiotic factors that limit plants from achieving their full genetic potential as crops, ornamentals, timber trees, or other uses. Plant monitoring is one of the most important tasks in any agriculture based environment. In this paper, we discuss about the implementation of a plant health monitoring system. Which will check some environment parameters like temperature, humidity and light intensity that has effects on plants. In addition, retrieve the soil moisture. All this information is sent by Arduino Uno dev boards to the Ubidots IoT (Internet of Things) cloud platform. If there are any deviations in the stored sensor value then alert message is sent to the user's smartphone.*

KeyWords: *Arduino Uno dev boards, Ubidots IoT cloud platform, Environmental factors, sensor, IoT, Wi-Fi*.

1. INTRODUCTION

International Telecommunication Union defines IoT as "A global infrastructure for the Information Society, enabling advanced services by interconnecting (physical and virtual) things based on, existing and evolving, interoperable information and communication technologies."

IoT is also defined as "The network of physical objects – devices, vehicles, buildings and other items – embedded with electronics, software, sensors, and network connectivity that enables these objects to collect and exchange data. The IoT allows objects to be sensed and controlled remotely across existing network infrastructure."

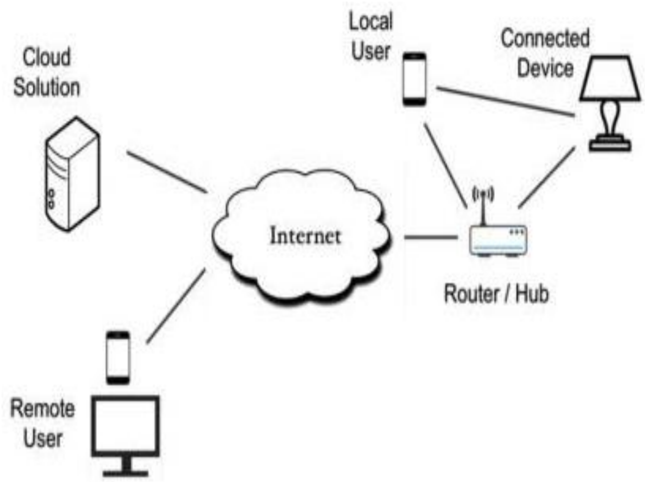

Fig. 1. Components of an IoT Application.

At its very basic level, IoT refers to the connection of everyday objects to the Internet and to one another, with the goal being to provide users with smarter, more efficient experiences. Some recent examples of IoT products include the Nest Protect smoke detector, August door locks and Nest thermostat. One of the known examples is the Nest thermostat. This Wi-Fi connected thermostat allows you to remotely adjust the temperature via mobile device. The potential value is that we can save money on utility bill by being able to remotely turn offair condition, which we forget to do before leaving the house.

Certain important factors such as temperature, humidity, light and the level of carbon dioxide has an impact on the productivity of plant growth. Therefore, continuous monitoring of these environmental factors gives information to the user, how each factor affects growth and how to maximize the growth of plants. In recent years, precision agriculture has become the trend in agriculture. Here the focus is mainly on understanding the environment through the interpretation of wide variety of data. The main idea of the system is to monitor the plants whether they get required amount of water and light. If there is enough moisture in the soil, the same will be reported to the user. This will help the user to give the resources to the plants every day without much manual effort and constantly monitor the health of a plant from a remote location.

Improvement of agricultural field has become biggest challenge for countries like India, so new technologies are to be adopted. We have implemented a novel methodology of physical parameter monitoring, data integration to the cloud, alert generation and predicting the future values. We have used Temperature humidity sensor, Soil moisture sensor and Light intensity sensor. These sensors have been installed in the agriculture field to collect the data, and thus data is stored into the cloud using Ubidots IoT cloud platform.

2. LITERATURE SURVEY

Mancuso and Franco [1], have done a similar research work in a tomato greenhouse in the South of Italy. The Sensicast device is used for air temperature, humidity and soil temperature with wireless sensor network and a web based plant monitoring system is developed. User can read the measurements over the Internet, and an alert message is sent to his mobile phone through SMS if there are any deviations from normal measurements. Sensor node will transmit the data of temperature and relative humidity in one minute interval to the Bridge node.

Teemu Ahonen, Reino Virrankoski and Mohammed Elmusrati [2], have done a research in Martens Greenhouse Research Center in the Narpio town in Western Finland, they had integrated three commercial sensors with Sensinode's sensor platform to measure four environmental key variables in greenhouse control. The system feasibility was verified in a simple star topology setup in a tomato greenhouse. The sensors used were SHT75 humidity/temperature sensor and TSL262R light irradiance sensor, and Figaro's TGS4161 CO2 sensor used. Application of the concept in the greenhouse: temperature, luminosity and humidity sensors measured climate variables and communicated directly with the gateway node. The gateway node acted as a coordinator and received the measured data from the sensor nodes. The maximal communication range, 15 meters was figured out in individual test where the distance between the coordinator and the sensor node inside the greenhouse dense flora was increased, the reliable communication range fell to one third in the greenhouse's dense flora.

3. SYSTEM ARCHITECTURE

The proposed IoT based plant health monitoring system consists of hardware and software modules as shown in Fig. 2.

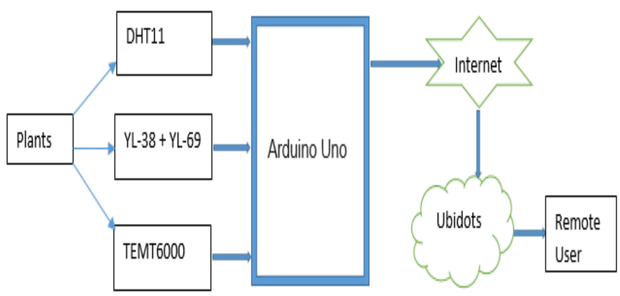

Fig. 2. Block diagram of IoT based plant health monitoring system.

Hardware used:

3.1 DHT11

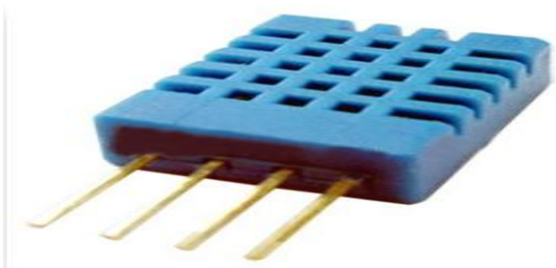

Fig. 3. DHT11 humidity and temperature sensor.

DHT11 is a Temperature and Humidity monitoring sensor using digital signal acquisition technique and temperature & humidity sensing technology. This sensor consists of a resistive type humidity measurement component and an NTC temperature measurement component, connects to a high performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability, low power consumption, cost-effective cheap sensor and suitable for Arduino. It has following specifications humidity measuring range 20% to 90% RH with an accuracy of 5.0% RH and temperature measuring range of 0 to 50 C with an accuracy of 2.0 C.

3.2 YL-38 + YL-69

YL-38 + YL-69 is a soil moisture sensor also known as hygrometer used to detect the humidity of the soil. Which helps to monitor the soil moisture of plants or build an automatic plant watering system. The sensor is made up of two parts namely the electronic board and a probe with two pads, that detects the water content in soil. When the soil is wet the output voltage decreases and when the soil is dry the output voltage increases. The output can be a digital signal low or high, depending on the water content. If the soil humidity exceeds a certain predefined threshold value, the modules outputs low, otherwise it outputs high.

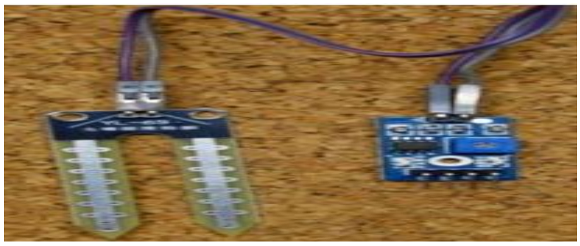

Fig. 4. YL-38 + YL-69 Soil Moisture sensor.

3.3 TEMT6000

TEMT6000 is a sensor to measure the light intensity so that we can know how much light the plant is receiving. Sensor acts like a transistor greater the incoming light, higher will be the voltage on signal pin. It detects the light density and reflect the analog voltage signal back to Arduino controller. It mimics the human eye, it does not react well to IR or UV light. TEMT6000 has following specifications like supply voltage range from 3.3V to 5.5V, operating temperature range 40 to 85 C and illumination range 1 to 1000 Lux.

Fig. 5. TEMT6000 Light Intensity Monitoring sensor.

3.4 Arduino

Arduino was born at the Ivera Interaction Design Institute as an easy tool for fast prototyping, started as a simple 8 – bit board to products for IoT applications. All Arduino boards are completely open source electronics platform based on easy to use hardware and software. It has been the brain of thousands of projects, from everyday objects to complex scientific instruments.

Arduino board can read inputs like light on a sensor, a finger on a button, or a Twitter message and turn it into an output activating a motor, turning on an LED, publishing something online.

Arduino board can be instructed by sending a set of instructions to the microcontroller on the board. Instructions are written in Arduino programming language and the Arduino software is used as Integrated development environment (IDE) for processing these instructions. Arduino offers many advantages over other microcontrollers such as cross platform – Arduino IDE runs on Windows, Macintosh OSX and Linux operating systems, inexpensive, simple programming environment

and open source. In this system Arduino Uno dev board is used as a microcontroller that can be programmed in C or C++. It has an IDE to simplify the development process. Arduino Uno can use an Ethernet shield or Wi-Fi shield so that it can send and receive data. It can be controlled remotely. Arduino Uno is perfect for IoT project based on sensors when the project requirements are sending sensor data to the cloud.

Fig. 6. Arduino Uno Dev Board.

Software used:

3.5 Ubidots IoT Cloud platform

Ubidots is the most important component of the plant health monitoring system. When building an IoT system based on sensors, dev board sends data to the cloud platform. These platforms store data and use it to build charts. An Ubidots IoT cloud platform is like a PaaS (Platform as a service) that provides some services useful in IoT ecosystem. These services enable dev boards connecting to remote services or other service providers. It would be expensive to connect Arduino to a remote service. These platforms make the heavy work. They execute a set of custom rules based on the incoming events from Arduino sensors. These events trigger external action like sending a short message. Most of these platforms have a free account that is useful to build an IoT Project.

4.EXPERIMENTAL SETUP AND RESULTS

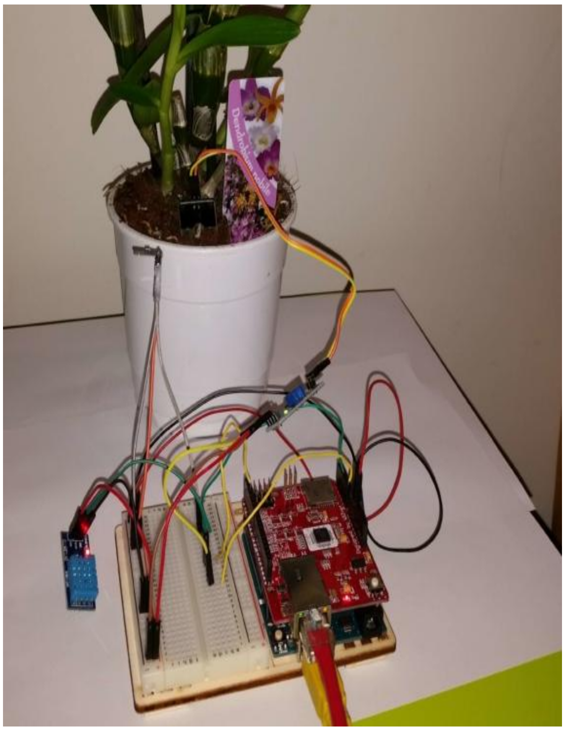

Fig. 7. Experimental Setup.

As shown in the figure the system consists of sensors like DTH11, YL-38 + YL-69 and TEMT6000 interfaced with Arduino Uno dev board. Arduino dev board is connected to IoT based cloud platform known as Ubidots using Ethernet or Wi-Fi. Ubidots will allow users to create a dashboard and to represent stored data as graph. DTH11 will monitor temperature and humidity, YL-38+YL-69 will monitor soil moisture and TEMT6000 monitors light intensity. These sensors will gather environment information and send the information to Arduino dev board.

IoT ecosystem uses several protocols to exchange information between components. Some of these protocols are widely used in other fields like HTTP and this protocol is used in IoT ecosystem too. It is very useful when we want to integrate IoT components to the rest of the world. Arduino Uno supports an HTTP Web server so that it handles HTTP connection.

Fig. 8. Flow diagram of Experimental Setup.

Arduino Rest API is used to exchange data from Arduino to other external systems. Arduino Rest API will read and send information to Arduino board. It will retrieve sensor values. Ubidots IoT cloud platform also uses Arduino Rest API mechanism, by using this mechanism when client sends a request Arduino replies with some data. Arduino Rest API works over HTTP protocol plays an important role in a client server scenario where Arduino acts as a server. Arduino Rest API uses a library called aRest. This library supports Rest services in different dev boards. Its open source and easy to use. Using the library we can implement Arduino Rest API paradigm because it supports reading pin values and writing pin values. Sensor values are stored in Arduino.

Now we need to configure the Ubidots so that the Arduino client can send data. This can be done using Ubidots web interface. While configuring the cloud, variable id's and authentication token are created. Using authentication token Arduino establishes a connection to the cloud. Arduino HTTP client sends each sensor value assigned with a variable id using JSON (Java Script Object Notation) service. Arduino is connected to the Ubidots cloud using an Ethernet shield then the data is stored in cloud and analyzed. Once the data, like sensor values, is stored in the cloud it is possible to access it using smart phones remotely.

Configuring Ubidots IoT cloud platform is shown below

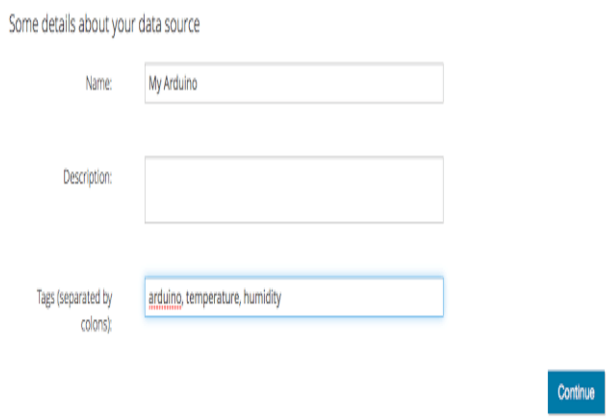

Fig. 9. Creating Ubidots project.

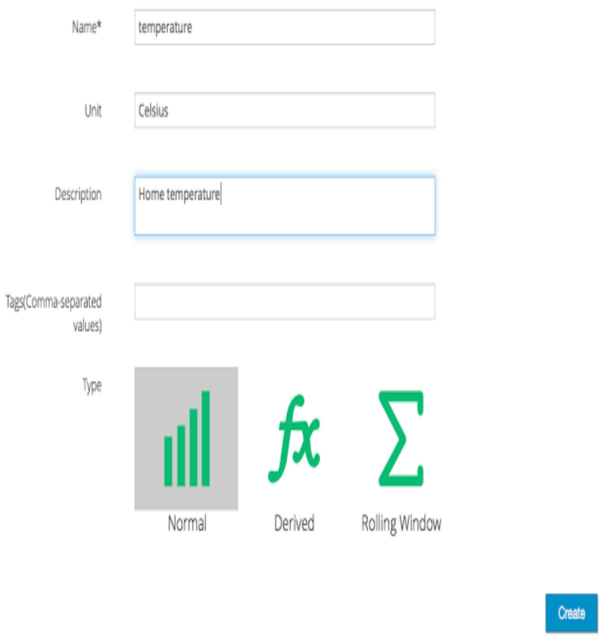

Fig. 10. Defining variables.

Fig. 11. Visualizing variables.

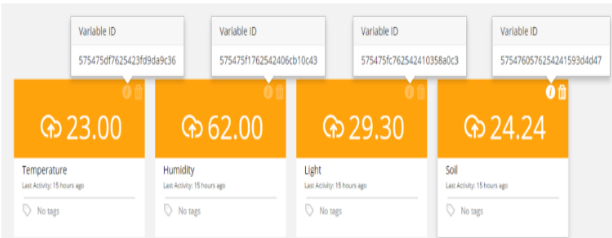

Fig. 12. Variable id configuration in Ubidots.

For secure access to the data in the cloud authentication token is generated as shown below

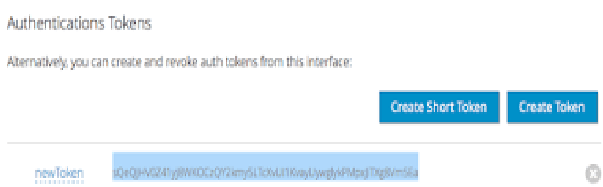

Fig. 13. Authentication token.

Results are generated in the form of dashboards and graphs using stored data from cloud.

Fig.14. Ubidots dashboard

Fig. 15. Graphical representation of temperature values stored in cloud.

Fig. 16. Graphical representation of humidity values stored in cloud.

Fig. 17. Graphical representation of moisture values stored in cloud.

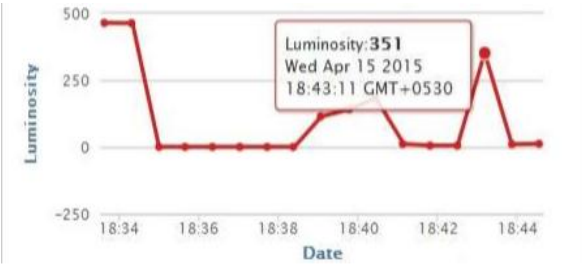

Fig. 18. Graphical representation of Light Intensity values stored in cloud.

5.CONCLUSION

The sensors and microcontroller are successfully interfaced with the cloud. The data is stored successfully and can be accessed remotely. All observations and experimental set up proves that this is a complete solution to monitor the health of a plant. User can have access to the data and can know if there are any deviations with respect to temperature, humidity, soil moisture and light intensity. Implementing this system will allow users like farmers to monitor and improve the yield of crops and overall production.

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BIOGRAPHY

Mr. Srinidhi Siddagangaiah has received B.E in Computer Science and Engineering from Atria Institute of Technology, Bangalore affiliated to VTU, Belgaum. He is currently working at Anabatic Technologies India Pvt. Ltd. as a Software Engineer.His area of interest are Cloud computing, Big data and Internet of things.