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RESEARCH PAPER

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GREENHOUSE AUTOMATION AND MONITORING SYSTEM DESIGN AND IMPLEMENTATION

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Abstract: In recent scenario of climate change and its effect on the environment has motivated the farmers to install greenhouses in their fields. But maintaining a greenhouse and its plantation is very labour intensive and majority of them perform vital operations intuitively. Also agricultural researchers are facing shortage of good quality of data which is crucial for crop development. Thus we have developed such a cost effective system using Internet of Things (IoT) technology which is focused on solving these particular problems, our system automates the greenhouse maintenance operations and monitor the growth conditions inside the greenhouse closely

Keywords: IoT; Agriculture; Automation; Monitoring; cost effective

I. INTRODUCTION

A. *Internet of Things (IoT)*

IERC(European Research Cluster on the Internet of Things) defines Internet of Things 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[1]. It is a concept and a paradigm that considers ubiquitous presence of variety of things or objects which are connected via wired or wireless communication networks and are able to interact, cooperate and communicate with each other in the environment with minimal or without any human intervention, this concepts revolutionizes user experiences and producers' understanding of user requirements and their production methods; which in turn will revolutionize our way of life as a whole. Primarily it suggests that virtually every things right from a conventional thermostat to a huge assembly line on a factory floor can be connected to the internet and can be converted into computers which will have a positive effect on their efficiency.

B. *IoT in Agriculture*

Very often farmer or Agriculturists rely upon their gut to figure out the vital operations which can have an adverse effect on their production, here sensor data in the fields or in the greenhouse can help farmers plan an optimum time to carry out the harvesting would then ensure that the crop is ready and the value generated is maximized. Thus agriculture is one of the largest use cases of IoT, besides this selective Irrigation, livestock monitoring, remote equipment operation and monitoring, predictive analytics for crops and livestock, etc. are other use-cases where IoT is most helpful.[2][3][4].

II. LITERATURE REVIEW AND SURVEY

The newer scenario of decreasing water tables, drying up of rivers and tanks, unpredictable environment presents an urgent need for proper utilization of water. To cope up with this use of temperature and moisture sensor at suitable locations for monitoring of crops is implemented in. [5]. We also visited few greenhouses and observed and recorded the working methods of the framers, which provided me a very clear idea how the maintenance and monitoring activities.[2] proposed the techniques for selection hardware,[6] provided basics and reference models on which an IoT system can be based and developed. Comparative study of some existing systems provided insights provides our first node to start, already available systems in IoT-powered gardening and agriculture, like Plantlink[7], Bitponics[8], and Harvest Geek[9] are either not available in India or are very costly which add up a considerable production cost overhead on the crops or Agro-based products.

TABLE 1. COMPARISON BETWEEN CURRENT SYSTEMS [10]

Systems	Parameters Measured	Additional features	Pricing
Plantlink	Soil Moisture	Plant-Specific Algorithms, Custom Alerts, Remote Monitoring	Nearly $69 per plant
Bitponics	Depends upon system connected	Growth plan and season specification, Analytics, multiple device support	Nearly $9 per plant per month, $499 for hardware
Harvest Geek	Depends on Bot Kits.	Bot Kits which makes it easier to install and modify	Not yet decided

III. SYSTEM OVERVIEW

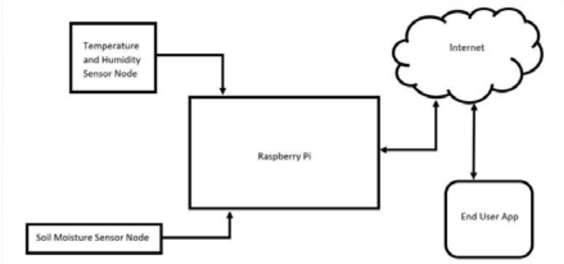

Figure 1. System Overview

The system consists of three sections; temperature and humidity sensor node, soil moisture sensor node, and PC or mobile app to control system. In the present system, every section is connected to raspberry pi directly or indirectly (via the Internet). They are interconnected to one central server (raspberry pi). The server sends and receives information from user end using internet connectivity. There are three modes of operation of the system; time-based mode, sensor based mode, and manual mode. In a time based and sensor based mode, the system makes a calculative decisions based on the plantation specific conditions and controls the actuation actions whereas in manual mode the user can control the operations using an android app or a desktop application.

IV. HARDWARE ARCHITECTURE OF THE SYSTEM

A. *Temperature and Humidity Sensor Node*

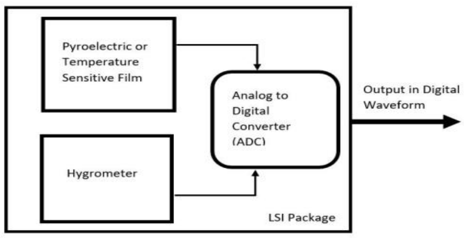

Figure 2. Temperature and Humidity Sensor Node

This node senses the temperature and humidity inside the greenhouse using a pyroelectric film for temperature and a hygrometer which is a Resistive type humidity sensors [11] that pick up changes in the resistance value of the sensor element in response to the change in the humidity. The changes recorded by both are sent to a common ADC system which will convert the analog form of data to digital form which is easy to decode and understandable by the server. For our system we have use DHT 11 sensor which is a composite sensor containing a calibrated digital signal output of the temperature and humidity, it works on the low power input, and is highly reliable as it can be operated in the temperatures till 50^{o}C and humidity till 80% RH.

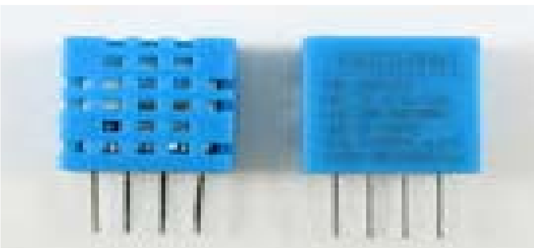

Figure 3. DHT 11 Sensor

B. *Soil Moisture Sensor Node*

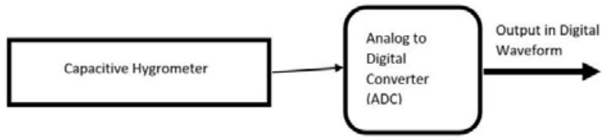

Figure 4. Soil Moisture Sensor Node

The node senses the moisture content based on capacitive effect, it consists of a hygroscopic dielectric material sandwiched between a pair of electrodes forming a small capacitor, in our case, it is the soil acting as a dielectric material. The dielectric constant of the hygroscopic dielectric material and the sensor geometry determine the value of capacitance in absence of moisture, at equilibrium conditions, the amount of moisture present depends on both the ambient temperature and the ambient water vapor pressure. At normal room temperature, the dielectric constant of water vapor has a value of about 80, which is much larger than the constant of the sensor dielectric material, ttherefore, absorption of water vapor by the sensor results in an increase in sensor capacitance.By definition, moisture content is a function of both the ambient temperature and water vapor pressure. Therefore there is a relationship between moisture content, the amount of moisture present in the sensor, and sensor capacitance. This relationship governs the operation of this node[11].

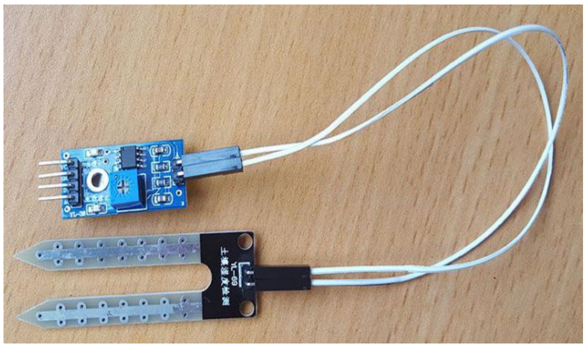

Figure 5. Capacitive Soil Moisture Sensor

C. *Raspberry Pi*

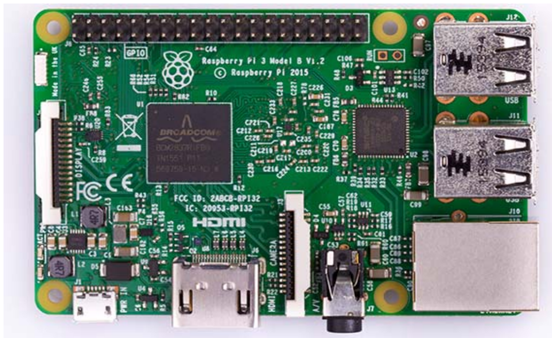

Figure 6. Raspberry Pi 3 Model B

Raspberry Pi is credit card size low-cost, high-performance computer, which is developed in the United Kingdom by the Raspberry Pi Foundation, we have used the model B of the third generation of raspberry pi which is shown in above figure. The primary reason to use this particular model its support for wireless connectivity, this model supports 2.4 GHz WiFi 802.11n (150 Mbit/s) and

Bluetooth 4.1 (24 Mbit/s) based on Broadcom BCM43438 FullMAC chip. It also has 10/100 Ethernet port. With its 40 GPIO (General Purpose I/O) pins peripheral interfacing becomes less cumbersome[12].

V. SOFTWARE DESIGN OF A SYSTEM

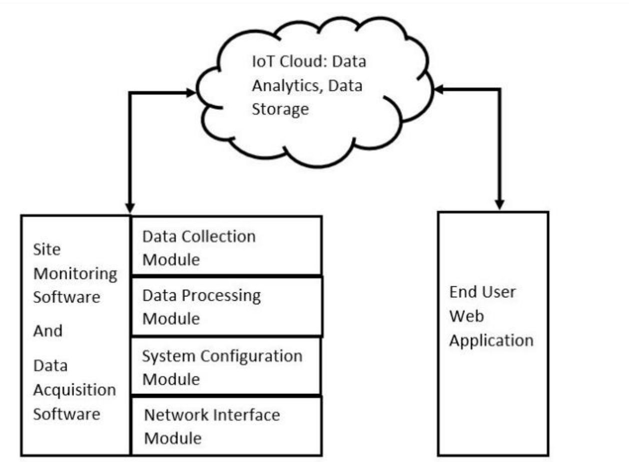

Figure 7. Software Design Overview

The Above figure depicts the overview of our software design. It consists of Site monitoring and Data acquisition software, IoT Cloud (containing Data analytics and storage and End user web application.

VI. IMPLEMENTATION

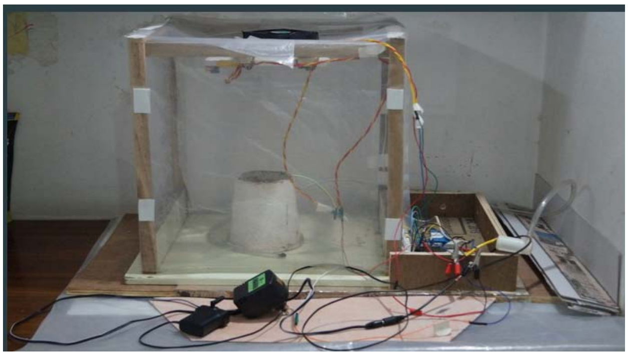

Figure 8. Humidity Analytics Results

The following figure depicts our prototype, the temperature and humidity sensor node, soil moisture sensor node are hardwired into the raspberry pi. The final python code is embedded in it as a high priority startup daemon. As soon as you will boot the raspberry pi the system will start functioning.

The sensors nodes interfaced using Standard Peripheral Interface Bus (SPI)communicate mutually in a half-duplex manner. The sensor nodes send data which is preprocessed using a dynamic linear queue and Arithmetic mean for error and noise reduction.Which is then published to an Open Source IoT Cloud where data analytics will be performed (as shown in following figures); then the cloud will send the data to the subscribed app using publish/subscribe pattern.

A. *Data Collection Module*

This module collects and decodes the digital signals input from the sensor nodes and extracts the usable data.

B. *Data Processing Module*

This module preprocesses the usable data for analytics to be done. Also, it uses this data for actuation purposes in timing and sensor based modes.

C. *System Configuration Module*

This module is used to configure the system primarily for setting threshold values and preprocessing fine tuning.

D. *IoT Cloud*

Being an IoT system on site we cannot load resource intensive the analytics code in the server thus using IoT cloud we can perform analytics and store the data collected for future use easily and efficiently.

E. *End User Web Application*

This will the user interface of the system, this module will contain a control panel where the user can watch and control the system easily.

For developing our software we have used python language as it is the most compatible with raspberry pi, also data preprocessing and web application development repositories are simple and efficient. As our cloud, we are using services of MathWorks® ThingSpeak™ and adafruit IO.

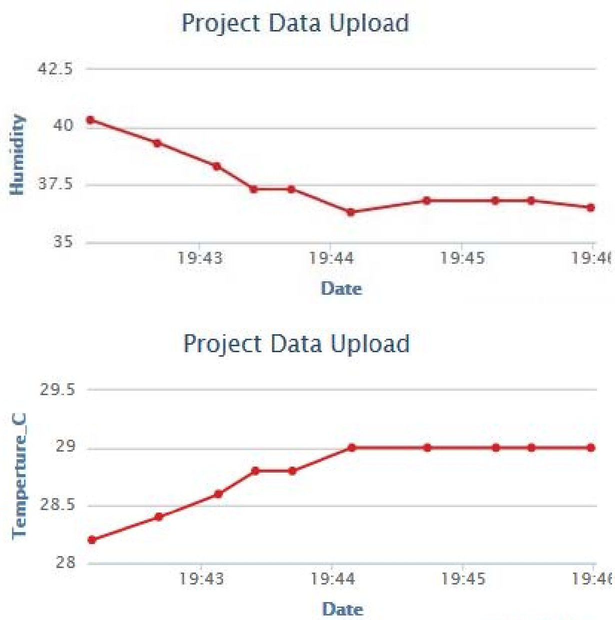

Figure 9. Temperature Analytics Results

There are three operation modesof the climate control system; Time Based, Sensor Based, and User Based. In sensor based mode the activities will be performed inside the greenhouse via installed actuators, if the sensor reads the temperature below the fixed threshold.In a time based mode the activities will be performed for a particular period of time and on a particular interval as specified by the user. And in user based mode the activities will be performed will be in control of the user of the system.

VII. FUTURE WORK

Here we have developed a working prototype which for has to converted to the product before installing it into a real world, thus our next task is to convert it to a product. Also, data security is one of the major issues in IoT-based systems thus we will also improve our prototype on this front.

VIII. CONCLUSION

Our system enables people to monitor and manage growing conditions of their greenhouse. The use sensor nodes, internet connection, and the cloud will deliver real-time updates about plants and help people grow plants more efficiently, with all observation and conventional tests results conclude that our project will provide a solution for automating greenhouse activities and irrigation activities. Implementation of such a system in the field can definitely help to improve the yield of the crops and overall production, and with its quality to cost ratio, it will be affordable to the majority of the agricultural community and also to agro-based industries.

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