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IoT-Enabled monitoring system for Plant Health Growth

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Abstract

In current scenario, plant health monitoring plays a crucial role in effective health maintenance of plants in climate changes. Internet of Things (IoT) played an efficient role in realizing the remote and real-time monitoring of any physical things and activities through internet connectivity. In this study we have proposed a system that is able to monitor the plant health with the assimilation of wireless sensors and wireless network. The proposed system is able to log the sensor values on the plants on the cloud server through internet connectivity.

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1. Introduction

Agriculture has grown into a rapidly developing sector around the world as the world's population grows. In order to satisfy the increasing need for food, the primary obstacle in the agricultural industry is to boost farm efficiency and yield without ongoing manual monitoring. Global warming, in addition to an increasing population, is an important issue in the agricultural sector [1]. Water scarcity and pollution are two hazards to the environment that affect large parts for the EU and a portion of the world. The impact of climate change is projected to worsen water scarcity and jeopardize the production of food. The supply of food is impacted by an array of environmental variables, such as the quality and accessibility of water, soil state, and the availability of energy. Several environmental issues have arisen because of agriculture's broad and exhausting practice over the last few decades [2].

Plant health is essential for the capacity of farmers to generate a high yield. Diseases and pests have an important effect on crop growth and agricultural output. The methods utilized in modern farming world require unaided eye assessment, which requires an enormous amount of time and effort [3]. Automatically evaluation of plant disease can be acquired at the earliest stages to avoid additional plant deterioration, leading to a rise in yield [4] [5]. Climate change has created numerous challenges that affect a variety of industries, including agriculture. The main challenge is to increase food productivity while addressing climate change. The latest developments of Information and Communication Technology (ICT) offers an approach to boosting the production of food while tackling climate change issues in agriculture. The proliferation of Wireless Sensor Networks (WSNs), Internet of Things (IoT) technologies, and, in particular, the introduction of Unmanned Aerial Vehicles (UAVs) has resulted in the development of cost-effective precision agriculture applications [6]. The paper examines the system's hardware and software development, including sensor choice, IoT environment, and system integration with mobile devices. Plant growth and field parameter monitoring systems powered by IoT have a chance to transform farming by offering farmers real-time access to essential crop data.

The remaining of this work is structured as follows:

- Section 2 presents an analytical review of the state-of-the-art related studies.
- Section 3 provides a detailed methodology of the proposed system for securing SSNs in IIoT scenario.
- Section 4 debates the performed experiments and the corresponding results.
- Section 5 concludes our contributions and findings.

2. Related Work

Arduino-based system for constantly tracking and regulating a variety of environmental variables in order to attain optimal growth of plants and production is proposed with the assimilation of multitude sensors such as, the soil moisture sensor, DHT11 sensor, pH sensor, and the LDR sensor [7]. Plant disease surveillance and classification IoT based system is proposed with the integration of a raspberry pi-based IoT device that transmits images of plants to categorize diseases and updates on environmental variables such as soil moisture, air temperature, humidity and pH in a MySQL database in real-time [8]. A study used the CC2530 chip in the development and execution of a ZigBee-based agriculture Greenhouse Environment tracking framework, with the wireless sensor. This system consists of front-end data acquisition, processing, transmission, and reception.

A cost-effective, open-source computerized re-configurable, storage-based remote monitoring system has been created. The platform streamlines the setting up of sensors, stores data, and provides an attractive dashboard for viewing the continuous data stream. An IoT based system for urban farming that uses soil moisture, humidity, and temperature as key farming parameters is proposed to determine when to start and stop irrigation based on the condition of the farm's land and gives the owner of the farm remote monitoring and control [9].

IoT can be used to provide environmental monitoring and irrigation facilities as a smart approach to the present farming issue. The system offers on-site and remote IoT monitoring of a greenhouse's humidity, temperature, light intensity, and soil moisture. A hybrid Internet of Things-based monitoring system is suggested for use in indoor farms. Amazon Web Services, IPv6 over low power wireless personal area networks, and controller area networks were used to implement the system.

3. System Description

The application of greenhouse in agriculture is vast. Greenhouses are used for growing flowers, vegetables, fruits, transplants and varieties of certain crops in a controlled environment, which is appropriate for the plants. The edible flowers are served in some good restaurants to grow them precise calculation is required. Sensor network can help to monitor and automate the activities in greenhouse. The objective of this chapter is to discuss the development of sensor nodes to monitor the growth of flower plants through XBee and internet of things. The system comprises of three sections- sensor nodes, local server and main server. Sensor nodes communicate to local server with XBee and then local server communicates the same data to main server through IoT. Fig.1. shows the generalized block diagram, sensor node is to be implemented on each flowerpot and communicating to local and main server.

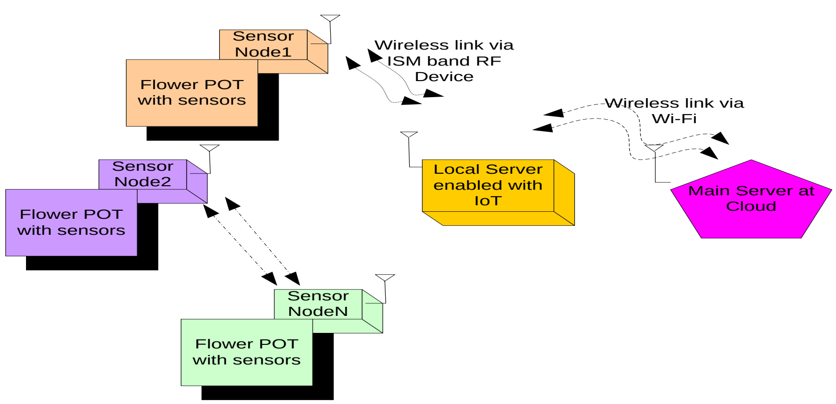

Figure 1. Generalized block diagram of the system

Figure 2 shows the block diagram of sensor node which comprises of Arduino, battery, water pump, light sensor, temperature/humidity sensor, soil moisture sensor, rainfall sensor, altitude/pressure sensor, Xbee.

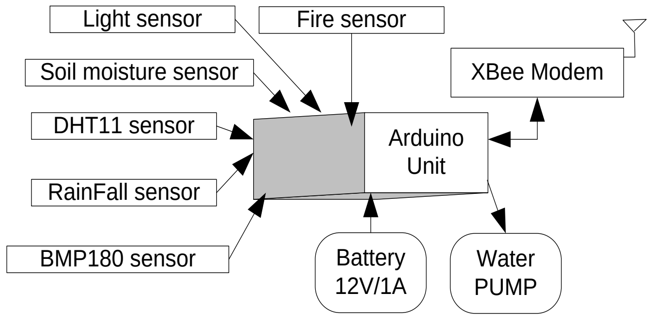

Figure 2. Block diagram of sensor Node

Figure 3 shows the block diagram of local server and PC as main server. Local server comprises of Arduino, battery, LCD, XBee, Wi-Fi modem.

Circuit Diagram for Sensor Node (Figure 4)

1. Connect Fire sensor output pin OUTPUT_FS to pin13 of Arduino Nano
2. Connect +Vcc and GND pins of sensors to +5V and GND of power supply
3. Connect RAIN sensor output pin OUTPUT_RS to pinA0 of Arduino Nano
4. Connect GND and +Vcc pins of RAIN sensors to GND and +5V of Power supply
5. Connect SOIL sensor output pin OUTPUT_SS to pinA1 of Arduino Nano
6. Connect + GND and +Vcc pins of SOIL sensor to GND and +5V of Power supply
7. Connect Light sensor output pin OUTPUT_LS to pinA2 of Arduino Nano
8. Connect +Vcc and GND pins of Light sensor to +5V and GND of Power supply
9. Connect pin 2 of DHT11 to pin 2 of Arduino Nano
10. Connect +Vcc and GND pins of DHT11 sensor to +5V and GND of Power supply
11. Connect SDA and SCL pins of BMP180 sensor to A4 and A5 pins of Arduino Nano
12. Connect GND and +Vcc pins of DHT11 sensor to GND and +5V of Power supply
13. Connect TX, RX, +Vcc and GND pins of Xbee to pins 6, 7, +5V and GND of Arduino Nano.
14. Connect +12V/1A power supply DC jack to DC jack of Arduino Nano.
15. Water Pump and exhaust Fan to D5and D4 pins of Arduino NANO using relay board

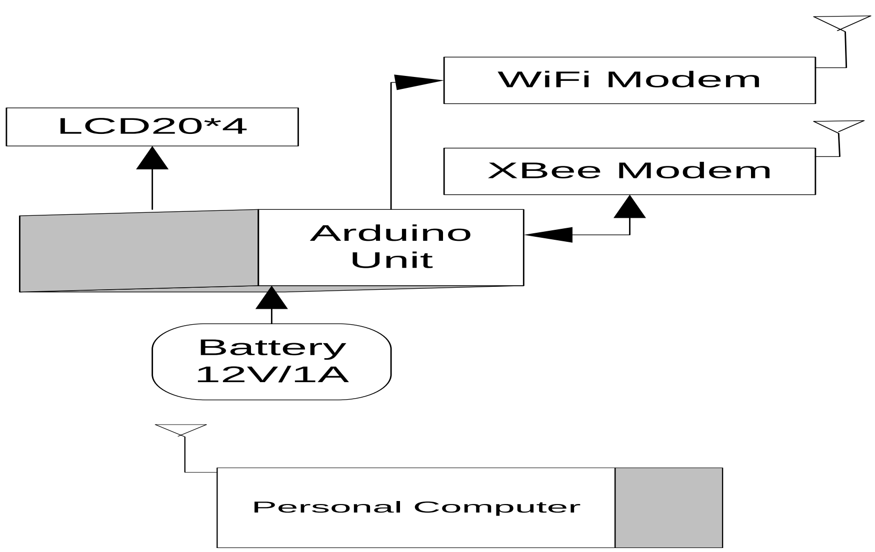

Figure 3. Block diagram of local server and main server (PC)

16. The base of NPN transistor 2N2222 is to be connected with pins of NodeMCU, in this case four pins D6, D7, D8 and D9.
17. Emitter of transistor is grounded.
18. The collector of transistor is to be connected with L2 of relay and Li of relay to positive terminal of 12V battery.
19. Negative terminal of battery is connected with ground.
20. One terminal of appliance (pump motor/exhaust) is connected with 'NO' of relay and other to one end the AC source.
21. Other end of AC source is connected to 'Common' terminal of relay.

Creating circuit diagram Local Server hardware (Figure 5)

1. Connect TX, RX, +Vcc and GND pins of XBee to pins 6, 7, +5V and GND of Arduino Nano.
2. Connect +12V/1A power supply DC jack to DC jack of Arduino Nano.
3. Connect D7 and D8 pins of NodeMCU to TX and RX pins of Arduino Nano
4. Pins RW, RS, and E of LCD is connected to pins GND, D0, and D1 of NodeMCU.
5. Pins D7, D6, D5 and D4 of LCD are connected to pins D5, D4, D3 and D2 of NodeMCU.
6. Pins 1,3 and 16 of LCD are connected to GND of power supply using power supply patch.
7. Pins 2 and 15 of LCD are connected to +5V of power supply using power supply patch.

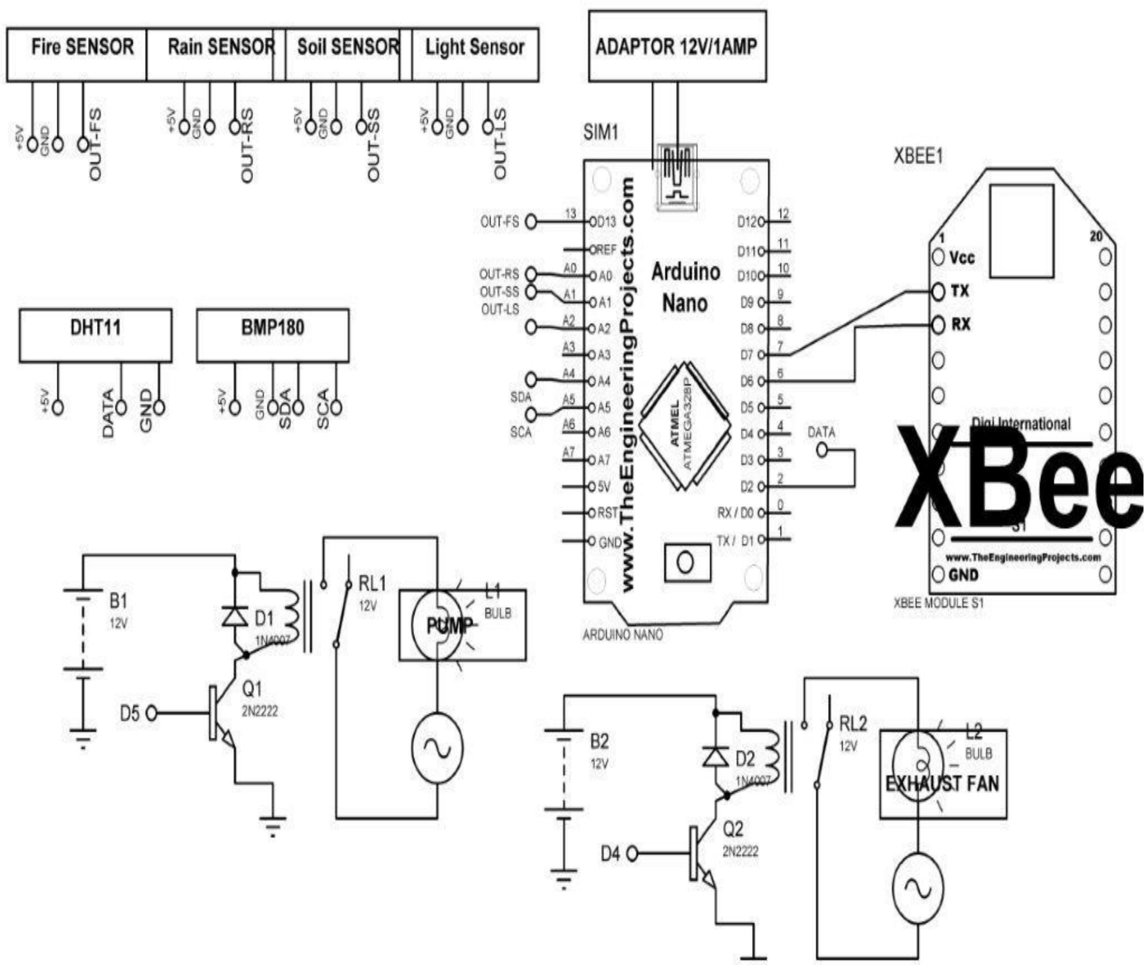

Figure 4. Sensor Node Schematic diagram

4. Software Development and Data Logging

A data logger is critical in an IoT-based plant growth and field parameter monitoring system for logging data regarding various field factors including as temperature, humidity, altitude, and air pressure (Fig. 6) this data can be used to monitor plant health and growth and make data-driven decisions about irrigation, fertilization, and other farming practices. A data logger can be linked to the sensors that measure the field parameters in order to log this data. The data logger takes data from the sensors at regular intervals and delivers it to the ThingSpeak server, a cloud-based platform that allows users to collect, store, and analyses data from sensors and other IoT devices. Temperature, humidity, altitude, and air pressure data can be logged in ThingSpeak when using the IoT-based plant growth and field parameter monitoring system. This data is collected by the data logger and sent to the ThingSpeak server at regular intervals. The data is then shown in the channel in graph form, allowing farmers to easily observe trends and changes in field parameters over time.

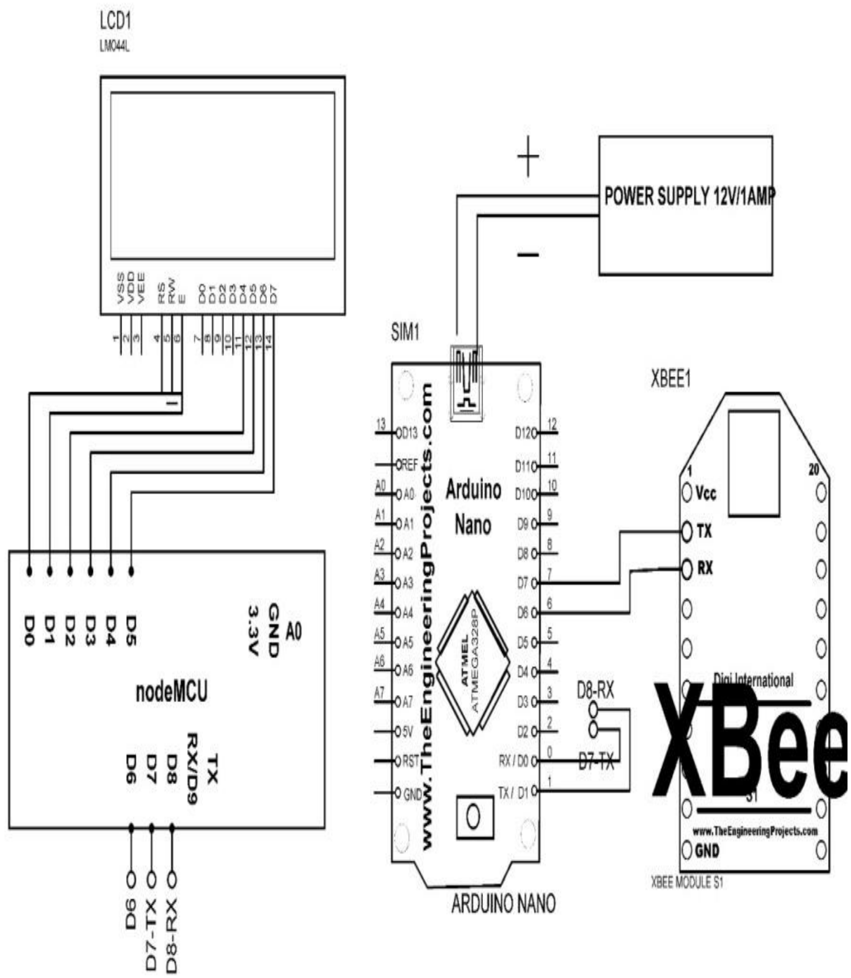

Figure 5. Local Server hardware Schematic diagram

For example, the data logger can be set to collect data every 15 minutes and send it to the ThingSpeak server. The data is then graphed in the channel to show the variations in temperature, humidity, altitude, and air pressure over time. This enables farmers to monitor trends and make informed decisions about whether to alter the temperature, when to water the plants, and when to apply additional nutrients or fertilizers. Overall, the usage of a data logger and ThingSpeak server in the IoT-based plant growth and field parameter monitoring system allows farmers to monitor the health and growth of their crops in a more efficient and data-driven manner, resulting in healthier and more productive plants.

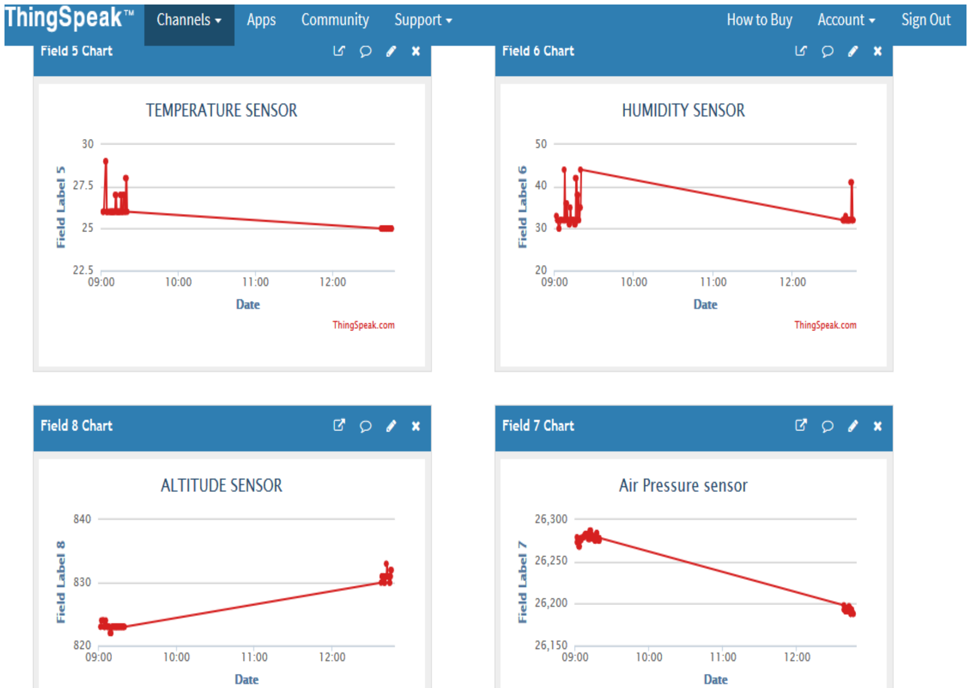

Figure 6. Charts from the field showing data received from local server

5. Conclusion

Currently, effective plant health maintenance in the face of climate change depends on plant health monitoring. Along with this, the United Nations has set a target of meeting the sustainable development goals by 2030 with digitalization and innovative infrastructure. In digitalization of an infrastructure, IoT is the primary technology. In this study, we have put forth a system that, by integrating wireless sensors and a wireless network, can track the health of plants. Through internet connectivity, the proposed system can log the sensor readings from the plants onto a cloud server.

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