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International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)
Vol. 1, Issue 1, April 2015

Automatic Management of Environmental Parameters Inside the Greenhouse Using Wireless Sensor Network

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***Abstract*— Greenhouse agriculture is one of the boon given to mankind mostly due to the advent of technology in the field of agriculture .The greenhouse provides the plants with the suitable environmental parameters which are necessary for their sustainable growth , the main problem lies in the process of maintaining such a stable environment inside the greenhouse which is overcame in this paper. The proper maintaining of the environmental parameters like CO_2 concentration and light intensity inside a greenhouse is unfolded in this paper.**

***Index Terms*— Actuator node, Coordinator node, Sensor node, TGS4161, WSN, ZC, ZED, Zigbee.**

I. Introduction

Environmental parameters like CO_2 concentration , light intensity and so on plays a vital role in photosynthesis according to [4]. So plants will be able to give their maximum yield if the environmental parameters are maintained at an optimized level. For the above said scenario greenhouse comes into play. The greenhouse is a closed environment within which the requirements of the plants are met, as a result the yield of the plants can be increased thereby taking the profit margin to a whole new level according to [1]. According to [2] the yield of the plants which are cultivated using greenhouse technology can be twice as much as obtained by traditional methods.

The major reason for the people are adapting greenhouse farming is because of the capability of providing an accurate optimized environmental condition for the plants and maintaining such condition thought out the production cycle and doing so without the human intervention is a major challenge which is undertaken in this paper. Due to the recent hype in the field of WSN, the embedded system side by side with WSN are used to create an automated greenhouse which provides proper support to the plants. Most of the studies like [3] [4] by Alejandra Jimeenez et all deals with monitoring of the environmental parameters , manually controlling the parameters respectively. This paper mostly deals with the automated control of the parameters inside the greenhouse.

Wireless technology emerged as a game changer in the field of communication and data transfer. By combining the wireless technology along with the embedded system , wireless sensor networks are emerged which in turn enhanced the capabilities of all the embedded devices. Due to such revolution the embedded devices now-a-days are

- more compact
- low power consumption
- attractive designs
- adaptive capabilities

The whole point of developing WSN is to monitor hazardous environment like nuclear reactor , but in due course they found their place almost in every fields from agriculture to war. The intruding properties which lead to the raise of WSN are

- they support mobility
- very limited power required
- less manpower for managing

For implementing WSN various communication protocols such as bluetooth, zigbee, Wifi, Ultra Wide Band (UWB) etc were in the line but the characters like low power consumption, low data rates, low cost made zigbee an outstanding choice for WSN.

Section 2 deals with the work done in the field of greenhouse farming. The section 3explains the proposed system which is followed by the section 4 which gives the graphical representations of the results obtained so far and section 5 concludes the paper along with the future works.

II. RELATED WORKS

Alejandra Jimeenez et all [3] proposed a system for monitoring and maintaining the temperature and humidity inside a greenhouse. The whole WSN is automated and the result obtained from both the automated environmental control and manual environmental control method is tabulated for further for further inferring. MSP430 processors are used in this system.

Xuemie Li et all [4] suggested a system which uses WSN for precision agriculture monitoring. The system consists of sensor and actuator nodes along with a PDA using it one can view the environmental conditions and control the parameters via actuators. The readings are logged periodically in a database. This system is cost effective and eco friendly.

Daeheon et all [6] proposed a system which is used prevent dew condensation on the leaf surface on the greenhouse

International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)
Vol. 1, Issue 1, April 2015

plants. The greenhouse plants are affected by fungus due to the dew condensation on the leaf surface. The system consists of three types of nodes namely sensor nodes for collecting sensed data , relay nodes for controlling the environmental parameters and base nodes for processing data. The collected data are logged in central servers.

Yu Chegho et all [7] proposed a system which explains the capabilities of the WSN. It also explains the sensing , actuation and communications involved in the WSN. It gives an acceptable factor opting Zigbee for WSN.

III. PROPOSED SYSTEM

Figure 1. Proposed wsn system

The proposed system comprises of a wireless sensor network which consists of a single coordinator node and a couple of sensing and actuator node as shown in the figure 1. The sensing and actuating mechanism both reside on a single node. All the sensor node will sense the real time data and forwards the data to the coordinator node which in turn process the sensed data as shown in the figure 2.

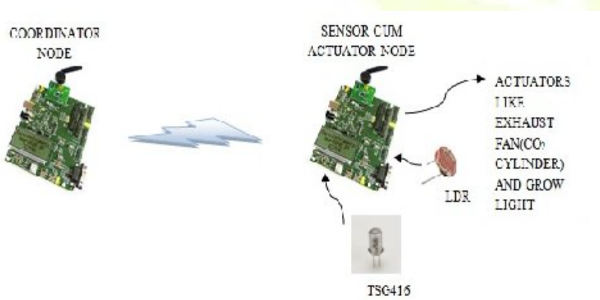

Figure 2. Proposed system

This paper uses two nodes one of which is programmed to be a coordinator node and the other is programmed to be a sensor as well as an actuator node as shown in the above figure 2.

Both the nodes make use of SOC type of controller with 8051 core and the controller will come with an inbuilt zigbee module. It supports the implementation Z-stack version 0.3 to 6.0 which are used for home automation. The Zigbee stack uses the frame format as given below

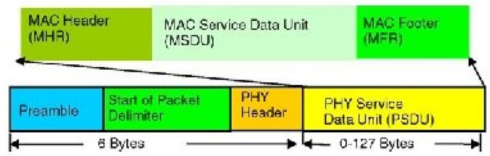

Figure 3. Z-Stack structure

When the binding of the nodes begins both the nodes will assign themselves random address for further communication between them. The data is transferred between the nodes by placing in the frame PSDU.

Carbon-di-oxide and light are the two major factors which are required by the plants for the process of photosynthesis as shown by the below formula

$$6CO_2 + 6H_2O \xrightarrow[\text{ENERGY}]{\text{SUNLIGHT}} C_6H_{12}O_6 + 6O_2$$

so for proper and enhanced yield by the plants inside the greenhouse the CO_2 and light intensity must be maintained continuously. For proper monitoring of the CO_2 concentration TGS4161 sensor is used which will provide the users with voltage values which is proportional to the concentration of the CO_2 present inside the greenhouse. TGS4161 is a solid electrolyte CO_2 sensor which offers a wide range of about 350 to 10,000 ppm. The sensor exhibit a linear relationship between ΔEMF and CO_2 concentration on a logarithmic scale.

The basic measuring circuit is shown in the figure 4.

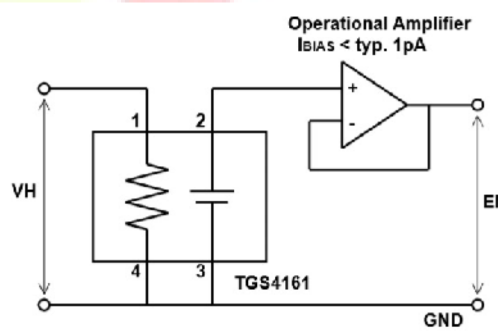

Figure 4. TGS4161 Measuring circuit

from the obtained EMF value the CO_2 concentration is calculated by using the formula given below

$$\Delta EMF = EMF1 - EMF2 \qquad (2)$$

The light intensity should also be given attention which is handled by using an LDR and the circuit for measuring the light intensity is given in the figure 5

International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)
Vol. 1, Issue 1, April 2015

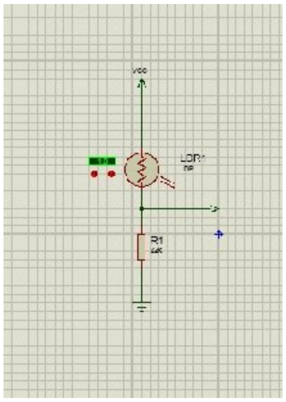

Figure 5. LDR circuit

By proper calibration of the circuit in the figure 5 gives an analog voltage which is proportional to the intensity of light.

The actuators for controlling CO_2 concentration and light intensity in real time should be a CO_2 cylinder controlled by a solenoid valve and a grow light respectively but for the demo in this paper exhaust fan setup and LED light are used for controlling CO_2 concentration and light intensity.

The coordinator node is a central standalone node which is used for providing a controlled environment by sending the control data to all sensor and actuator nodes connected to it. The sensor node is the node which is connected with all the sensors and it will bind itself with the coordinator node and the coordinator node after analyzing the data , if the data crosses a particular maximum or minimum threshold values it generates and sends a control data which in turn when received by the sensor nodes will urge the sensor nodes to shift into actuator mode and start the control mechanism using PWM and driving the motor driver circuit as given in the below figure 6.

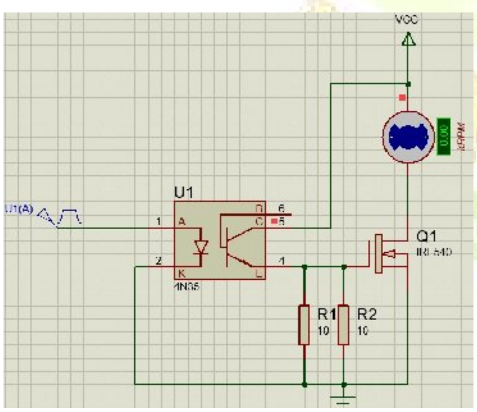

Figure 6. Motor Driver circuit

IV. EXPERIMENTAL SETUP

The setup is made up of two development boards one of which is a coordinator node and the other is the sensor node. The sensors and actuators are connected with the sensor node which are connected with the coordinator node via zigbee protocol and they transmit the real time values to the coordinator node. The coordinator node will drive the actuator mechanism as shown in the figure 7 to maintain the constant and optimal environment.

Figure 7. The Experimental setup of the WSN network

V. RESULT

For the above said setup the values of the CO_2 concentration and light intensity is recorded for about a week duration and evaluated. The series 2 and 3 in below figure 8 and figure 9 shows the values of the CO_2 concentration and light intensity in the outside and the controlled environment respectively. The CO_2 being the light gas will raise above and so it can be removed by using exhaust fan system and can be maintained.

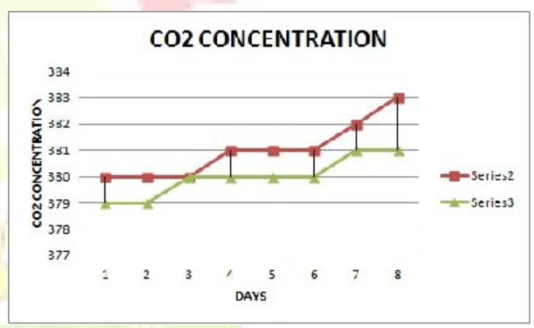

Figure 8. CO_2 Concentration in Controlled environment VS outside environment

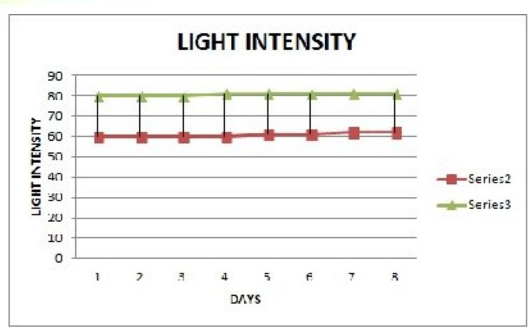

Figure 9. Light Intensity in Controlled environment VS outside environment

International Journal of Advanced Research in Biology, Ecology, Science and Technology (IJARBEST)
Vol. 1, Issue 1, April 2015

VI. CONCLUSION AND FUTURE WORK

The proper monitoring and control of the greenhouse parameters like CO_2 concentration and light intensity is done successfully using the WSN technology. The control can be enhanced by using CO_2 cylinders and grow light for more accurate management of the environmental parameters. The whole proposed system can be enhanced in future by interfacing further more sensors in the sensor nodes.

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