WIRELESS SENSOR NETWORK (WSN) FOR GREENHOUSE ENVIRONMENT MONITORING

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Abstract: Traditionally, agriculture has been used as a manual method to carry out the production process. However, technology is advancing and Wireless Sensor Networks (WSN) gain an increasing interest and has got importance in many applications that involve remote monitoring and control. So to find a technological alternative which allow functional and efficient management of greenhouse, a special kind of system of WSN is deployed. Monitoring of various parameters like temperature, humidity and soil moisture is an important issue for many crops like tomato, cucumber, capsicum etc.

The data collection, monitoring and connected hardware to the crops allows for higher yields and lower cost, with less impact to the environment. A very important issue related to the use of WSNs is an energy source for wireless sensor nodes. Battery energy source can be deployed to provide power supply to these wireless sensor nodes.

The wireless sensor nodes are responsible for a measurement of temperature, humidity and soil moisture parameters and sending this acquired data to network coordinator i.e. master node. The coordinator will be microcontroller with ZigBee module. The network coordinator node is responsible for reception of measured data from wireless sensor nodes and data transmission to the computer or mobile devices.

Keywords: Wireless Sensor Network (WSN), Greenhouse, Zigbee, Network coordinator, Wireless sensor node

A. INTRODUCTION OF WIRELESS SENSOR NETWORK

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to monitor physical or environmental conditions. A WSN system incorporates a gateway that provides wireless connectivity back to the wired world and distributed nodes.WSN consist of small size wireless nodes are used which are more cost efficient as compared to cable system , also installation of WSNs is fast, cheap and accurate.WSN have a wide range of application including agriculture. The application of WSN technology in the field of agriculture has increase the effectiveness and efficiency of farmer and helps them in making better and accurate decision. Thus a wireless sensor network consisting of small size wireless sensors is an attractive and cost efficient option to build requires measurement system.

To make automation system work properly within ultra modern and big greenhouses, several measurement points are required to trace down the local climatic parameters at different locations. Use of cabling for monitoring would make the measurement system expensive and vulnerable to their problems. Moreover, the cable measurement points are difficult to relocate once they are installed.

Due to these facts a WSN consisting of small sized wireless nodes are used which are more cost efficient as compared to cable system; also installation of WSNs is fast, cheap and accurate. WSN have a wide range of application including agriculture. The application of WSN technology in the field of agriculture has increased the effectiveness and efficiency of farmer and helps them in making better and accurate decision. Thus a wireless sensor network consisting of small size wireless sensors is an attractive and cost efficient option to build required monitoring system.

The parameters like temperature, soil moisture and humidity are measured. Wireless technologies like GSM and Zigbee are used to improve the crop productivity.

B. LITERATURE SURVEY

1. ARM based Agricultural Field Monitoring System

The system of ARM based Agricultural field monitoring system is mainly focused on modernizing the irrigation technology in agriculture and also to provide adequate irrigation in particular area. The set up consist of ARM7TDMI core. It also gives the detail information about field condition to the user through SMS. But ARM7TDMI is not easily programmable and its cost is high as compared to PIC. So to overcome this problem PIC micro-controller is used and android application is developed. [1]

2. Greenhouse monitoring based on Zigbee wireless sensor network

It is mainly focused on monitoring greenhouse using 8051 micro-controller.8051 is a 8 bit processor. It is simple but slow and outdated. Zigbee has many advantages and it is compatible with 8051 but due to disadvantage of 8051, PIC and RS232 are used to increase compatibility.[2]

3. Remote monitoring using sensors in greenhouse agriculture

It proposes a monitoring system that can remotely monitor and predict changes of humidity and temperature level in the greenhouse atmosphere. In this project they only measured the temperature and humidity, but soil moisture is not measure in this project .This is the disadvantage, so to overcome this soil moisture parameter is considered.[3]

B. COMPONENTS SPECIFICATIONS

1. Microcontroller PIC18F4550

The features of High-Performance RISC CPU of PIC18F46K22 are:

- C Compiler Optimized Architecture:
- Optional extended instruction set designed to optimize re-entrant code { Up to 1024 Bytes Data EEPROM
- Up to 64 Kbytes Linear Program Memory Addressing
- Up to 3896 Bytes Linear Data Memory Addressing
- Up to 16 MIPS Operation
- Pin diagram is as shown in figure 1.

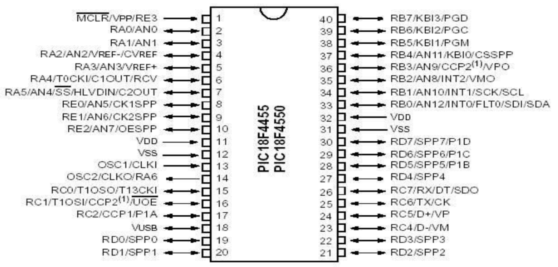

Fig. 1 Microcontroller PIC18F4550

2. Zigbee

ZigBee is the most popular wireless mesh networking standard for connecting sensors, instrumentation and control systems. ZigBee, a specification for communication in a wireless personal area network (WPAN), has been called the Internet of things. ZigBee is an open, global, packet-based protocol designed to provide an easy to-use architecture for secure, reliable, low power wireless networks. ZigBee and IEEE 802.15.4 are low data rate wireless networking standards that can eliminate the costly and damage prone wiring in industrial control applications.[4] The Zigbee module is as shown in figure 2.

Fig. 2 Zigbee module

3. Humidity Sensor SYHS-220

To measure humidity, amount of water molecules dissolved in the air of polyhouse environments, a smart humidity sensor module SYHS-220 is opted for the system under design. The sensor is as shown in figure 3.

Following are the Features of SYHS-220,

- Rated Voltage- 5 V DC
- Rated Power- less than 3.0mA
- Operating Temperature- 0 - 60 degree Celsius
- Operating Humidity- 30-90

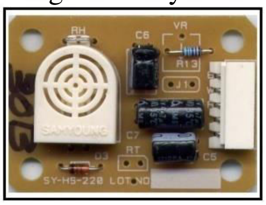

Fig. 3 Humidity Sensor

4. Soil Hygrometer

Most soil moisture sensors are designed to estimate soil volumetric water content based on the dielectric constant of the soil. The dielectric constant of soil increases as the water content of the soil increases. The soil moisture sensor used in the system is shown in figure 4. The measurement of the dielectric constant gives a predictable estimation of water content.

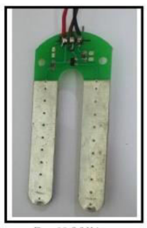

Fig. 4 Soil Hygrometer

5. Temperature LM35

The LM-35 series are precision integrated temperature devices with output voltage linearly proportional to the centigrade of temperature. The LM-35 does not require any external calibration. The low output impedance and precise inherent calibration makes it easy to interface with other devices. The LM35 is as shown in figure 5.

Following are the Features of LM-35

- Operates from 4 V to 30 V
- Rated for Full 55 degree Celsius to 150 degree Celsius Range { Suitable for Remote Applications
- Low-Cost Due to Wafer-Level Trimming
- 0.5 degree Celsius Ensured Accuracy (at 25 degree Celsius)

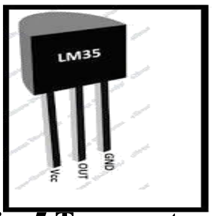

Fig. 5 Temperature LM35

C. SYSTEM ARCHITECTURE

The brief overview and block diagrams are shown in figure 6. The process begins with the sensing of greenhouse environment parameters. The sensors are deployed are at spatially distributed locations and called as leaf nodes.

The sensors sense the desired parameters and generate a proportional electrical volt-age corresponding to the sensed parameter. The typical output from the sensor is an analog voltage. The analog voltage is then converted to its equivalent digital form. The analog-to-digital converter (ADC) is employed for that task. The output of ADC is fed to controller for processing the data. Since some controllers are already equipped with internal ADC module, it is beneficial to use such controller. It will reduce the space of additional ADC chip on the PCB.

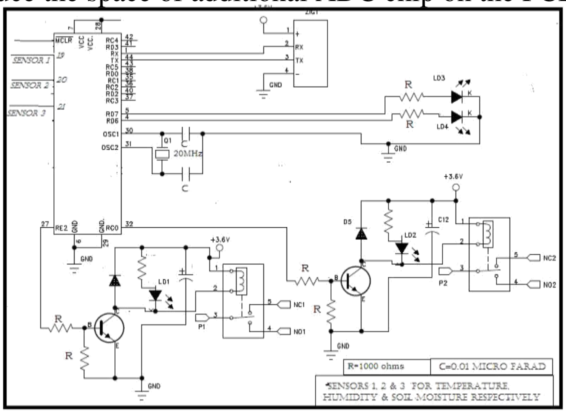

Fig. 6 System Architecture

The controller after receiving the data of all parameters from all nodes, sends the data to the master node via Zigbee, that is, IEEE 802.15.4 standard. The master who is also equipped with Zigbee module receives the data. The master node is equipped with additional GSM modem. Hence after receiving data from all leaf nodes, the master node will send data to the user via application. Thus a user friendly interface of the system needs to be provided.

D. DESIGN OF MASTER NODE

The figure 7 below shows the circuit diagram of master circuit using PIC16F877A microcontroller, ZigBee module and GSM modem. An extra LCD is also included to see the process is being executed. The pin number1 of the controller is the master clear input. It is active low. Pins 11, 32 and 12, 31 are for VDD and VSS respectively. The external crystal oscillator of 20 MHz is connected between pins no. 13 and 14. Pin no. 23(SDI) and 26(Rx) are used as serial input and pin no. 24 (SDO) and 25(Tx) are used as serial output. The ZigBee module and GSM modem are connected to microcontroller via MAX232 IC [35,36]. This IC is responsible for voltage conversion between input data from controller and out data level to the modules. Also, used in vice-versa case.

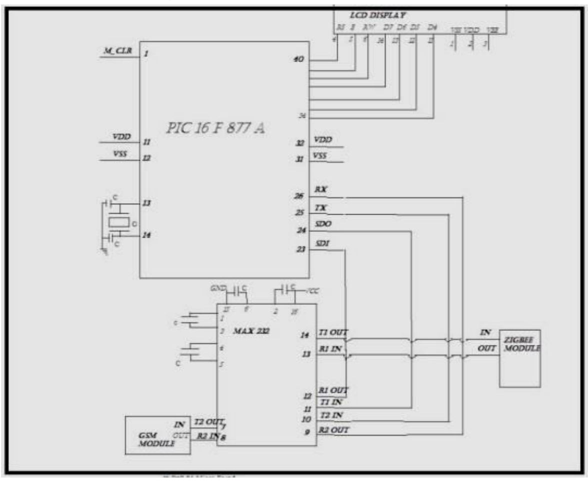

Fig. 7 Design of Master Node

E. DESIGN OF LEAF NODE

The figure 8 below shows the circuit diagram of the leaf node using PIC18f46K22 controller and ZigBee. The sensors are connected to pin no. 19,20 and 21 which corresponds to RA0, RA1 and RA2 respectively. These pins are input-output data pins which have an in-built analog-to-digital converter. The data from these ports is sensed and converted to its digital equivalent.

The sensor parameters which are converted to digital data are transmitted to ZigBee through pin no. 44 which is serial-out pin of the microcontroller. To facilitate control mechanism of the parameters in the greenhouse, additional relays are added to the leaf node. The output of the microcontroller is connected to the base of the transistor. When the output goes high, the base voltage of the transistor goes above threshold voltage and the transistor is turned ON. The exact opposite operation is performed when the output of the microcontroller is low.

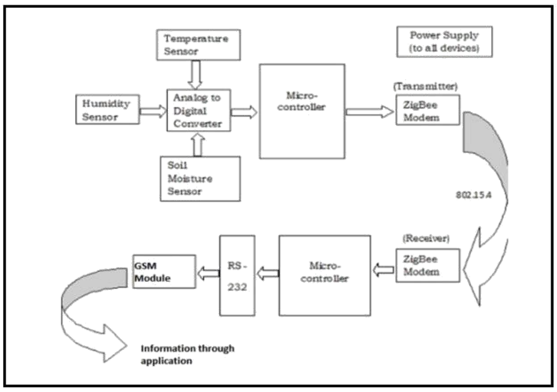

Fig. 8 Design of Leaf Node

F. PLACEMENT OF NODES

Number of sensor nodes depends on the size of greenhouse. About 200 nodes are sufficient if the size of green house is 35mx 200 m. This is the physical size of the targeted area. It is under the range of sensing capacity of the hardware. The sensor nodes can be of two types A & B. Where type A is climate sensor for outside, and type B is climate sensor for the inside of the greenhouse. Type B sensors can be placed at a distance of 10 to 15 meters of diameter, to capture precise environmental condition. The placement of nodes is as shown in figure 9. [6]

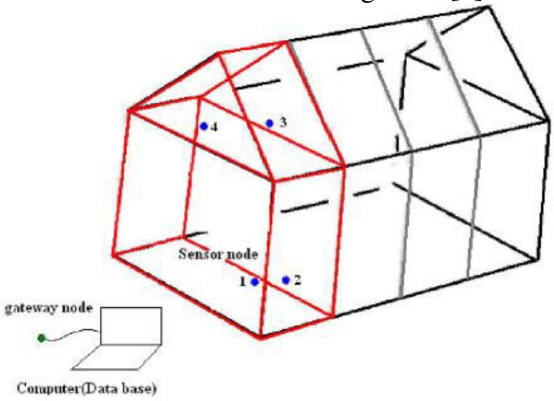

Fig. 9 Placement of Nodes

G. WORKFLOW OF MASTER AND LEAF NODES

The working algorithms for master and leaf node is a given in figure 10 and figure 11. It ensures a smooth and real-time working of the system in coordination for hardware and software.[5]

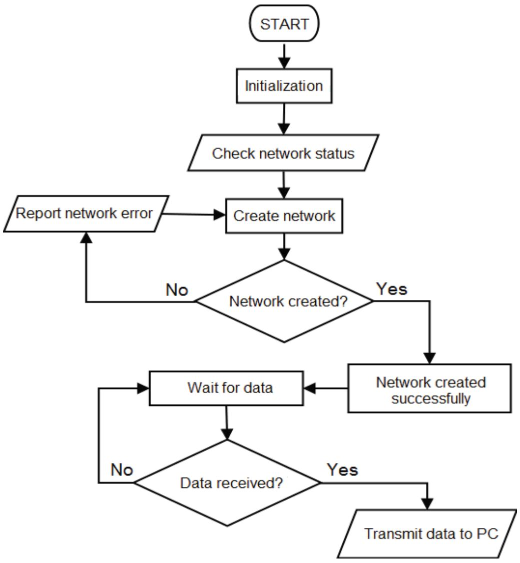

Fig. 10 Algorithm for Master Node

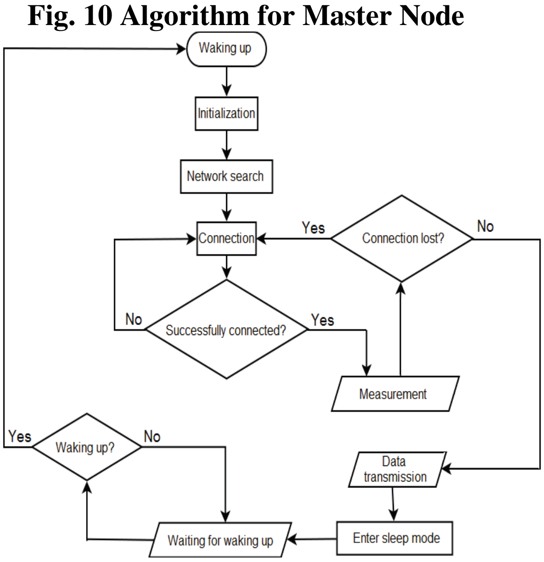

Fig. 11 Algorithm for Leaf Node

H. EXPERIMENTAL SETUP AND RESULTS

Three leaf nodes and one master node are designed. All the leaf nodes are subjected to different conditions to check the performance of the system. The node 1 is subjected to cold environment, low soil moisture and natural humidity. Hence the temperature and soil moisture reading should be low. The second node was kept in natural environment. The reading shown by node 2 should give actual environmental parameters around us. The soil moisture sensor of this node is kept open. The node 3 is subjected hot environment, and high soil moisture. The readings of soil moisture and temperature from this node should be high. To above all, an extra sensor, that is, light sensor is also added. There variations show that the nodes were kept at different places and hence had different illumination levels. The below figure 12 and 13 shows the setup of leaf node and the master node respectively. The node shown in figure 12 is leaf node 1. The temperature sensor of this node is subjected to cool environment i.e. put in plastic bag and immersed inside cold water. The soil moisture sensor is inserted in dry soil, but the soil not completely dry. Little moistness can be felt.

Similarly, the node 3 also subjected to the conditions mentioned above.

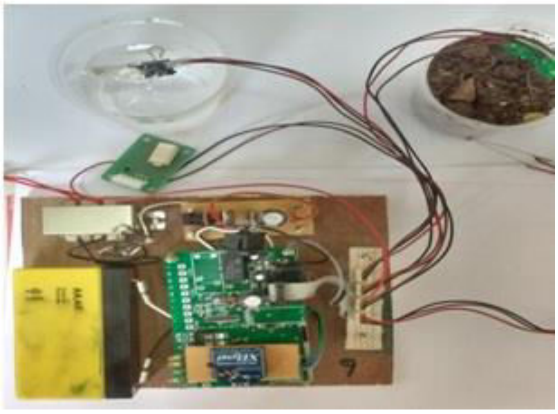

Fig.12 Setup of Leaf Node

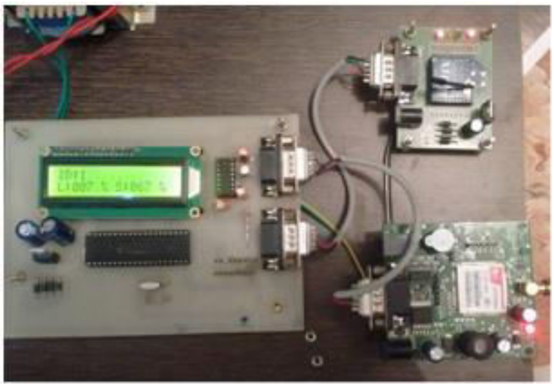

Fig. 13 Setup of Master Node

The results of all nodes is fected to server and made available for analysis purpose. A website is launched for this purpose and all parameters are uploaded on it. Sample cnapshot of this website is as shown in figure 14.

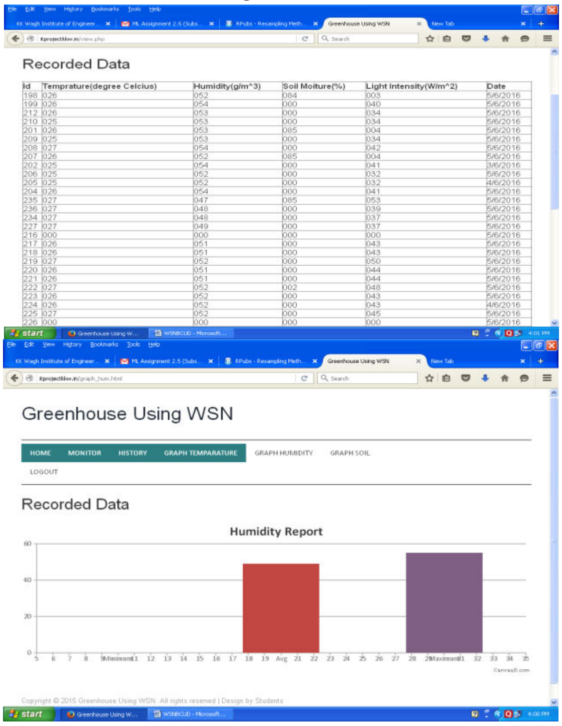

Fig. 14 Snapshots of Data Collection on Website

I. CONCLUSION

The system to monitor greenhouse parameters; ambient temperature, relative humidity and soil moisture sensor was developed using wireless communication technique. From the reading it is clear that the system work quite satisfactorily and it can be deployed for actual use in greenhouse, It can be kept long distance up to 100 meters light of sight and real time monitoring for parameter of greenhouse and the information can be obtained of greenhouse at regular intervals. It has the advantages of not needing cables since wireless data exchange mechanism will be followed. The system will consume less power due to use of Zigbee technology. The cost of the system will be kept as low as possible. The number of nodes for adding or deleting will be flexible. The use of the system will not be complex so that any common farmer can easily use for his purpose.

The use of Zigbee technology makes the system best for agricultural communication. Also, the components like micro-controller, sensors and RF transceiver are selected which will be most suitable and will be easily available. Hence the system is expected to perform efficiently in real world application.

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