Wireless Sensor Network in Greenhouse

S.U. Zagade[1], Prof. Dr. R.S. Kawitkar[2]
Department of E& TC, Sinhgad College of Engineering, Pune, India.

Abstract

Monitoring & control of greenhouse environment play an important role in greenhouse production & management. This paper consists of design & implementation of a WSN that can monitor the air temperature & humidit in greenhouse. This can help farmers to understand the environmental conditions & they can adopt different methods to increase the crop production. The system is integrated with small size application specific sensors & radio frequency modules. All monitored parameters are transmitted through a wireless link to cellular device for analysis. A cell phone is used instead of computer terminal keeping mind that system will be used by farmers & considering power management.

1. Introduction

Wireless sensor network consists of specially distributed autonomous devices using sensors to monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion at different locations. Application areas for WSNs include geographical monitoring (seismic activity), precision agriculture (soil monitoring), habitat monitoring (tracking of animal herds), transportation (traffic monitoring), military systems, business processes, & in future, possibly cooperating small things [1].

One example of WSN is automatic meter reading system[3]. Here ZigBee module is connected to each customer's meter. The GSM module takes data from the ZigBee modules which are in its range and transfer it to central computer. Another example is wireless sensor network deployed in crop field[4]. Temperature, humidity & light intensity in brinjal field is sensed by different sensor nodes deployed in field. This data is transferred to centralize computer for monitoring purpose.

Greenhouse is kind of advanced hortical facility which changes plant growth environment creating suitable conditions for plant growth, avoiding the outside season change & the adverse effects caused by bad weather. Greenhouse is playing important role in production of out of season vegetables, flowers as well as high value of delicate plants. The purpose of green house environment is to increase crop yields and to improve quality of crops [2].

The optimal plant growth depends upon air temperature, humidity & active radiation of light, which results in maximum photosynthetic activity. Crop field monitoring using WSN thus represents a class of network applications enormous potential benefits for the farmers and society as a whole. In this work, wireless sensor network has been implemented, that can monitor the air temperature, humidity and ambient light intensity in a crop field. Continuous monitoring of these key environmental variables can help farmers in improving the quality and productivity of crops. Since, early detection & suppression of plant fire is crucial in restricting them, a plant fire detection scheme has also been incorporated in the system. The design also includes implementation of necessary network services, power management, status monitoring of sensor nodes & remote data access.

The design is based on integration of two different wireless technologies for increasing the wireless range & for reducing the cost. There are different points at which sensors are deployed in greenhouse so that area gets increased. Increase number of measurement points should not dramatically increase the system cost.

The remainder of this paper is organized is as follows: Section 2 presents the system architecture of WSN describing the functionality of individual components & how they operate together. Section 3 represents the hardware & sensor nodes design along with coordinator node. Section 4 provides result & discussion. Section 5 provides the concluding remarks & outlines the future work.

2. System Architecture

Fig. 1 shows topology of WSN implemented in design of WSN for greenhouse. There are total three sensor nodes, each sensing temperature & humidity in addition to general purpose computing &

networking. The computation module on each sensor node is a programmable unit that performs computation & bidirectional communication with other sensor node. It interfaces with the digital sensors on the sensor module & dispatches the data according to the application needs. Since the wireless communication range provided by the radio frequency (RF) module is more than 1500m, the sensor node can be widely separated. Sensor node 1 & sensor node 2 transmit their data through the wireless communication link to sensor node 3 which acts as a coordinator node. The coordinator node aggregates the data in time multiplexed manner, which helps in avoiding collision of data transmission. Coordinator node also acts as a gateway node between two different wireless technologies. The advantage of making node 3 as a coordinator as well as gateway node is to increase area covered by system. It transmits its collected data along with its own data to the cell phone using short message service (SMS). The cell phone is used instead of computer terminal to increase the distance, to create simplicity in the network as well as to minimize the power consumption.

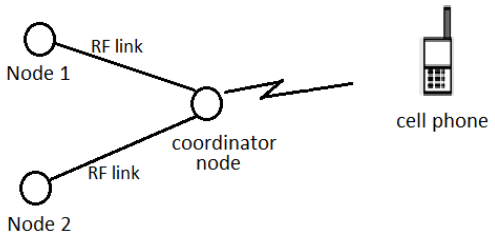

Figure 1. Topology of WSN

3. Hardware & Sensor Node Design

The network formed consists of three nodes where each sensor node consists of small size sensor & general purpose computing elements. The sensor nodes can be deployed at various locations in a greenhouse to monitor environmental changes. The main components in sensor node are outlined below:

A. RF module

ZigBee is intended for wireless application that requires low data rate, low power consumption, low cost, and secure networking. ZigBee layered on top of IEEE 802.15.4 standard which defines the physical (PHY) layer and Medium Access Control (MAC) layer. ZigBee Alliance itself defines the application and security layer specifications. The stack can be drawn in fig 2. The IEEE 802.15.4/ZigBee standard defines dual PHY layer, which are 2.4 GHz and 868/915 MHz.

The ZigBee-Pro RF modules manufactured by Digi are used to provide the required wireless RF communication link among sensor nodes. The modules are designed to meet IEEE 802.15.4 standards & capable of providing reliable delivery of data between compatible devices. They operate within the ISM 2.4 GHz frequency band & provide a wireless communication range of 200m in open space. The modules are programmed using dedicated programming kit to make them compatible for wireless communication.

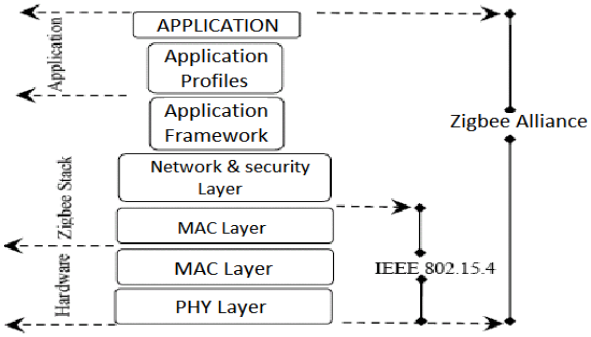

Figure 2. ZigBee/IEEE 802.15.4 Stack

B. Sensors

Small size, low power consumption, easy integration & replacement makes sensirion SHT71 [5] a perfect solution for greenhouse. It is the temperature & humidity sensor providing calibrated digital output. Temperature & humidity accuracy of the sensor is ± 0.4 ^{0}C & 0.2 % respectively.

Sensor does not require any external components for signal conditioning which saves valuable PCB area. Also, due to the digital nature, output is more immune to noise & external disturbances. The start-up time in sensor is very low. Therefore current is not needed for a long time during initialization thereby reducing the power consumed. The power saved can be used to perform other computing task. Another advantage is that sensor can be deployed quickly in greenhouse since no calibration is required.

C. Sensor node

The basic model of the sensor node 1 & node 2 is shown in fig. 3. Each sensor consists of SHT71 temperature humidity multi-sensor module which monitors the environmental variables in the greenhouse. Sensors are soldered to the PCB along with necessary passive components such as resistors & capacitors. The sensor node operates as a basic measuring node with RF transceiver & Atmel ATmega16L controller operating at 1MHz. The microcontroller acts as a CPU & performs all the computations & input-output operations required for the working of sensor mode. Sensor is integrated with the microcontroller through two general-purpose input-output pins. One is bidirectional for

exchanging data between microcontroller & sensor & other is for providing clock to the sensor.

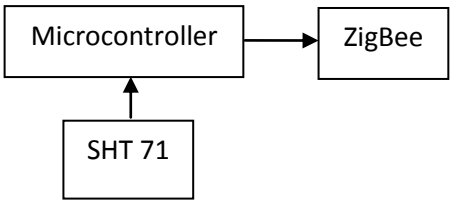

Figure 3. Basic Model of Sensor Node

D. Coordinator node

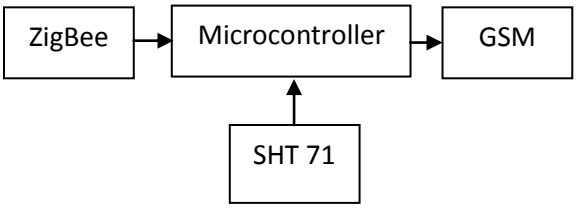

Figure 4. Coordinator Model

Coordinator node acts as a sensor node as well as gateway node. It receives the data from other sensor nodes using RF communication link. It also contains SHT71 which is used to measure temperature & humidity. It acts as a gateway node because it connects two different wireless technologies as shown in fig. 4. It transmits its own data along with other sensor node's data through GSM module to cell phone.

A sensor node data is transferred to microcontroller through UART interface. Microcontroller performs all the processing of data which is collected from sensor nodes 1 & 2. It also processes & combines the data of its own along with the data gather from node 1 & node 2 while transmitting. The data is transmitted with the SMS service provided in GSM module. The main components in sensor node are outlined below:

E. GSM service

GSM stands for Global System for Mobile communication. In 1980's, cellular telephone system was already used in Europe. Each country use different protocol and frequency for this cellular technology. Each of this technology is interoperable and analogue. Since the technology was growing rapidly, in 1982 Group Special Mobile was formed among Europe countries. This group standardized cellular communication protocol which we know as the Global System for Mobile communication nowadays.

Most GSM networks in the world operate in 900 MHz or 1800 MHz bands. However, some countries are using different frequency since the allocated frequency had already been used. GSM use Time Division Multiple Access (TDMA) and Frequency Division Multiple Access (FDMA) for multiple access method and use Gaussian Minimum Shift Keying (GMSK) for its modulation method. GSM architecture consists a lot numbers of network elements which will form a Public Land Mobile Network (PLMN). Generally the network elements can be divided into:

a. Mobile Station (MS)

MS is device at customer's side. Handset and Subscriber Identity Module (SIM) card include in this network element. International Mobile Subscriber Identity (IMSI) and Mobile Subscriber Integrated Services Digital Network (MSISDN) information are stored in this SIM card.

b. Base Station Sub-system (BSS), consist of :

– Base Transceiver Station (BTS), connect directly with Mobile Station (MS)
– Base Station Controller (BSC), control the BTS

c. Network Sub-system (NS), consist of:

– Mobile Switching Center (MSC) for cellular-to cellular or cellular-to-PSTN interconnection
– Home Location Register (HLR), store information about subscriber permanently
– Visitor Location Register (VLR), store subscriber's information
– Authentication Center (AuC)
– Equipment Identity Registration (EIR), store all subscribers information

d. Operation and Support System (OSS)

OSS is network component which function as a controller such as fault management, configuration management, performance management, and inventory management.

F. Short message service

Short message service (sms) provided by GSM is used here for sending the data to the observer for analysis. Short message service is a mechanism of delivery of short messages over the mobile networks. The short message service is realized by the use of the Mobile Application Part (MAP) of SS7 protocol. Messages are sent to a short message service centre (SMSC) which provides a 'stored & forward' mechanism. It attempts to send messages to SMSC's

recipients. If a recipient is not reachable, the SMSC queues the message for latter retry.

G. Power supply

Monitoring of the environmental behavior should be done for duration of complete season. Power supply to sensor node is provided with 3.3 V DC & 220 mA. Step down transformer is used to convert AC mains supply to DC.

The power supply unit is integrated with the sensor node board. To withstand the variable weather conditions, the entire sensor node board is mounted in an acrylic enclosure that does not affect the sensing functionality. Since an acrylic covering is transparent to infrared & radio frequency, it does not obstruct the wireless communication.

H. Reliability

The short message service provided by the GSM is the most reliable system. Even if the cellular device is out of range all the messages are delivered along with time information when it comes with range.

I. User friendly system

Nowadays every individual is familiar with cell phones. Hence, it is better to use cell phones instead of any other device as displaying purpose. It also saves the energy consumed by bulky system because energy consumed by overall system including cell phone is very less.

4. Result & discussion

The proposed WSN system consisting of 3 sensor nodes has been tested. Fig. 5 shows a one sensor node out of three sensor nodes. Each sensor node measures temperature & humidity. Node 1 & node 2 transmits their data to sensor node 3 which combines it's data with received data & transmits all data to cell phone for observation purpose. LCD display is mounted on each sensor node to measure corresponding node data as well as verification purpose.

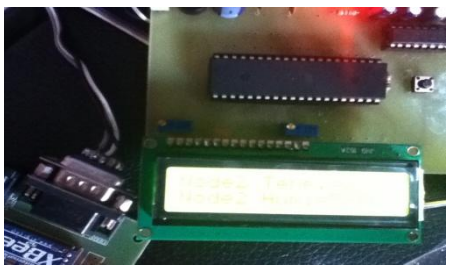

Figure 5. Sensor Node

The temperature and humidity values measured by the sensor nodes is shown in Fig. 6. The outdoor wireless communication range of a RF module is 1500 m.

Figure 6. Temperature & humidity measurements

5. Conclusion

Wireless monitoring system designed using with different sensors having capability to measure different types of environmental parameters is beneficial in greenhouse. It helps farmers to increase the crop production with better quality. It also has capability to detect the fire.

References

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