

Autonomous Online Expansion for the Environmental Applications

Shweta S. Badgi¹, N. A. Dawande²

¹University of Pune, Dr. D. Y. Patil College of Engineering, Ambi-Talegaon, Pune, India

²University of Pune, Department of Electronics and Telecommunication Engineering,
Dr. D. Y. Patil College of Engineering, Ambi-Talegaon, Pune, India

Abstract: *In modern greenhouses, several measurement points are required to note down the local climate parameters in different parts of the big greenhouse to make the greenhouse automation system work properly. This paper presents design and development of environmental applications monitoring using ARM7 and ZigBee. For sensing different environmental parameter, a sensor node is developed which has feature of wireless communication using ZigBee trans-receiver. The data sensed by the sensor is digitized by internal ADCs of LPC2138 microcontroller. The microcontroller LPC2138 executes very fast with low power consumption. In this paper we are using the autonomous expansion of the system i.e if one slave which is not in the range of the master but it is in the range of the slave which is in turn is in the range of the master then its contents will be accessible by the master unit. Here we are using different types of sensors such as temperature, light and humidity. We are using ZigBee wireless sensor network as a communication platform for real-time monitoring. This paper summarizes an idea that can be carried out to provide an efficient control mechanism greenhouse through the implementation of an infrastructure of Wireless Sensors Network to control environmental parameters.*

Keywords: WSN, ARM7, Zig Bee, greenhouse monitoring

1. Introduction

The project describes the design of wireless sensor network based on RF technology. It is mainly used for collecting and transferring the various monitoring information like temperature, light, humidity i.e. the environmental conditions. The wireless sensor network consists of spatially distributed autonomous sensors to monitor physical or environmental conditions and to co-operatively pass the data of the sensors through the network to a main location. The topology of wireless sensor network can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between hops of the network can be routing or flooding.

Here we are making use of Zig-Bee based network for environmental applications. We are making use of master and slave structure or the application. The range of the ZigBee is 30 Mt. so the whole area cannot be covered by single master slave combination. So we are covering the whole field by master slave combinations. We will be making use of nearest neighbor protocol and collision avoidance protocol.

The function of a greenhouse is to create the optimal growing conditions for the full lifecycle of the plants [3]. Using autonomous measuring stations helps to monitor all the necessary parameters for creating the optimal environment in the greenhouse. It introduces a wireless sensor network that was used for the purpose of measuring and controlling the greenhouse application. Continuous advancements in wireless technology and miniaturization have made the deployment of sensor networks to monitor various aspects of the environment increasingly flexible. Climate monitoring is vitally important to the operation in greenhouses and the quality of the collected information has a great influence on the precision and accuracy of control results. Currently, the agriculture market field incorporates

diverse data acquisition techniques. Normally, the best type of acquisition system is chosen to control algorithm to be used. Traditionally to monitor the climate and control systems, all sensors are wide spread through the greenhouse and connected to the device performing the control tasks. This equipment use time-based data sampling techniques as a consequence of using time-based controllers.

The applications of WSNs typically include monitoring, tracking, and controlling. Some of the specific applications are habitat monitoring, object tracking, etc. In a typical application, a WSN is spread over in a region where it is meant to collect data through its sensor node. In modern greenhouses, several measurement points are required to trace down the local climate parameters in different parts of the big greenhouse to make the greenhouse automation system work properly. If cabling is used for the measurement system, then this would make the system vulnerable and expensive. Moreover, the cabled measurement points are difficult to relocate once they are installed. Thus, a wireless sensor network (WSN) consisting of small-size wireless sensor nodes equipped with radio and one or several sensors, is an attractive and cost-effective option to build the required measurement system. Continuous advancements in wireless technology and miniaturization have made the deployment of sensor networks to monitor various aspects of the environment increasingly flexible.

2. Literature Survey

Numerous research works in this field published in last few years has been studied giving following information. Agriculture has been always considered in countries as one of the most important productive sectors [1]. Traditionally, agriculture has used manual methods to carry out the production process. However, due to the enhancement in technology today it is possible to atomize certain processes in order to achieve higher efficiency in managing.

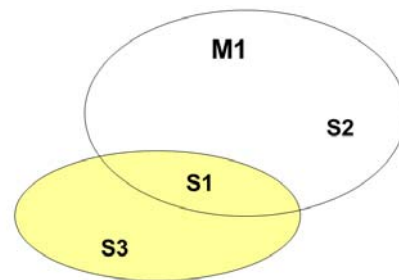
Precision agriculture provides all the attention for harvest information, work management and growth information. Also, the production in agriculture enhancement is due to the advance progressing through the introduction of sensor networks technologies combined with actor networks to monitor and control agriculture applications. The crucial aspect to enhance the production is to prevent diseases in the crops which is possible by environmentally monitoring and controlling in green houses. There are many researches being carried to adapt the new technology of wireless sensor network (WSN) to agriculture fields. Greenhouse monitoring and control based on a TINI embedded Web server unit which collect data and routes it from local sensor/actuator networks to a base station has been studied and done by the researcher . Also, Zhou et al has introduced an architecture and application of a ZigBee; network combined with event-based control techniques [3].The environment of a greenhouse having a WSN has been monitored. The WSN integrates wireless communication embedded computation, sensor and micro electro-mechanical system (MEMS) that has have gained increasing attention during recent years. The development of smart WSN is done effectively with MEMS technology. The resources are limited in terms of power, processing and computing for the actor sensor nodes, also the size must be comparatively small as possible so that the nodes can provide with many particular applications. To process the necessary action the sensors need to sense the environment, measure and make use of the decision making unit to. The automated and wireless communication with the physical world using sensors nodes that capture the data of the environment and a group of actor nodes which can be responsible of decision making is known as a wireless sensor actor network (WASN). WASN provides suitable actions which affects the environment under supervision. Sensor nodes and actor nodes that communicate wirelessly with the sink node or the main node gathers the data by sensor nodes and then sends to the main node. Main node will then evaluate and analyze the data received then infers a suitable action to be taken. The main node sends the action command, till then the actor node waits. Actor nodes connected to devices that perform adjusting to the environment under vision.

Wireless sensor networks consist of tiny devices that usually have several resource constraints in terms of energy, processing power and memory [2]. In order to work efficiently within the constrained memory, many operating systems for such devices are based on an event-driven model rather than on multi-threading. Continuous advancements in wireless technology and miniaturization have made the deployment of sensor networks to monitor various aspects of the environment increasingly possibilities. Wireless Sensor Networks have recently received a lot of attention within the research community since they demand for new solutions in distributed networking. A common scenario associated with these networks is that tiny nodes, equipped with several sensors and hardware for wireless communication, are deployed randomly and in large numbers within a certain area. In order to report the data they gather in their proximity to an interested application or user, nodes connect to their neighbors and send valuable information on a multi-hop path to its destination. The concept of wireless sensor networks is based on a simple equation:

Sensing + CPU + Radio = Thousands of potential applications

As soon as people understand the capabilities of a wireless sensor network, hundreds of applications come into the mind. It seems like a very good combination of modern technology. An effective wireless sensor network requires a combination of the sensors, radios and CPU's with proper understanding of the both capabilities and limitations of each of the underlying hardware components, as well as a correct understanding of modern networking technologies and distributed systems theory. Wireless sensor networking is one of the most exciting technologies to emerge in recent years. Advances in miniaturization and MEMS-based sensing technologies offer increases by orders of magnitude in the integration of electronic networks into everyday applications. Traditional microcontroller design strategies have not reached the best possible power consumption, especially for the specialized application set of sensing networks. Power efficiency is a prime concern in wireless sensors, whether powered by a battery or an energy-scavenging module. Trends in miniaturization suggest that the size of wireless sensors will continue to drop, however there has not been a corresponding drop in battery sizes.

3. Overview of the System

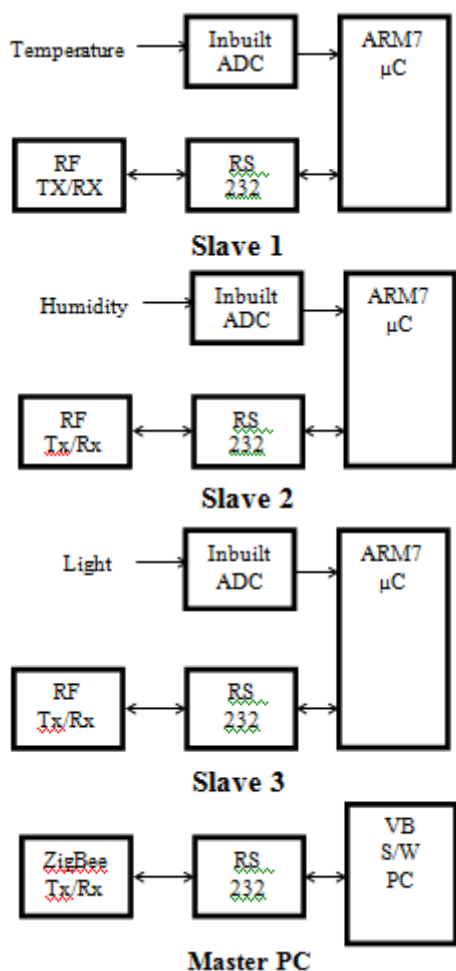


In our system we have;

- One master PC terminal
- Three slaves terminals

In total we have 3 slaves. The idea is that if one slave goes out of range of the PC then communication fails. So we are placing three slaves which will be placed in such a way that they will be always in the range of PC master. Therefore PC master will communicate to slaves via wireless ZigBee module.

3.1 Block Diagram



3.2 Block Diagram Descriptions

In the block diagram we can see that there is one master and three slaves. We have a main PC master terminal which has the VB software on it. It monitors the status of all the slaves which covers the whole area. Using a master Request and slave response. In this system the Master monitors the data of different parameter. The three slaves are under the PC based masters supervision. Thus the PC master will communicate to the slaves through Wireless ZigBee module and RS 232.

3.3 PC Master

We are monitoring the system based on the wireless network for environment application, we have master and slave structure for the application. So at the host terminal PC we are having the connection via ZigBee technology and RS 232 communication. A wireless sensor network such as one using ZigBee can penetrate walls and be used in places where a wired network is either not suitable or cannot be established. The advances in the wireless technology have made it possible to establish a network just by placing the communicating nodes at the required places and switching on the transmitters in them. The range of Zigbee is about 30 meters to 100 meters. So, the whole area is covered by Master slave combination.

3.4 Collision Avoidance Protocol

Here we are using a master request and slave response protocol. In the request frame the master mentions the slave ID and sends request for all the slaves. The request frame is received by all the slaves who are in the range. The slaves which are in the range of the master receive the incoming frame and store it in its internal RAM memory. Here the slave ID is checked. If the incoming slave ID matches with their own slave ID then they accept the frame and send the parameter back to the master. If there is a mismatch in the ID then the slave discards the frame.

3.5 Co-operative Communication

Co-operative communication is used to make sure that slave is always in the range of the master. These units are basically repeater unit which will enhance the data signal, when the slave is not in the range of master. Here request is first given to the slave who is in the range of the master. The frame transmitted by PC master will contain the slave id from whom the data is to be retrieved

3.6 Nearest Neighbor Protocol

In nearest neighbor protocol, the master sends request on broadcasting mode. The slave nearest to the master will receive and compare its own ID with the slave ID. If they match then the slave will sent the data to the master which means that the slave is in the range of the master which is nearest path to the master. If the slave ID does not match, then slave will forward the frame to the other slaves which are in its range. Any slave in the range of this slave but out of range of master will receive the frame and will send the data to the master via shortest path.

4. Hardware Design

The requirement of the hardware components used to implement this system is summarized as follows:

Hardware Component:

1. ARM 7TDMI (LPC 2138) [13], [14], [15]
2. ZigBee [9]
3. Temperature Sensor [LM35D]
4. Light Sensor[LDR]
5. Humidity HY 220 [16]

5. ZigBee Functioning

The standard for wireless personal area network i.e. IEEE802. 15.4 Which is the base for ZigBee a short-range, low rate of data wireless network technology [20], [18]. The data rate of ZigBee is between 10kbit / s and 250 Kbit / s, so it is suitable for low-cost and low power wireless transmission applications. Therefore they are expected to operate for a longer period of time with limited power.

ZigBee can build up to a few tens of thousands of wireless transmission module consisting of wireless-data transmission network platform through the network node, which is very

similar to the existed CDMA mobile communications network or GSM Network. And each network node can increase the distance from the standard 30 meters to several hundred meters. ZigBee technology has low rate of data and the characteristics of the smaller range of communication, which also informs that the ZigBee technology is suitable for carrying data traffic smaller business. The stack standard 802.15.4 protocol which possess a powerful networking capability is the base for ZigBee .

It ZigBee operating frequency band is ISM 2.4 GHz (Industrial Scientific & Medical Band) IEEE 802.15.4 [20], [21] which specifies the physical and data link protocols for low-rate wireless personal area networks (LR-WPAN). There are 27 radio channels of the three frequency bands in the physical layer. Channel 0 is located from 868.0 to 868.6 MHz, which gives a data rate of 20 kbps. Channels 1-10 ranges from 902.0 to 928.0 MHz, provides a data rate of 40 kbps. Channels 11-26 are ranges from 2.4 to 2.4835 GHz, each with a data rate of 250 kbps.

IEEE 802.15.4 devices are expected to operate for a longer period of time with limited power. Therefore, energy conservation is a critical issue.

6. Proposed Software Design

To do the reliable monitoring and management of sensed data an interactive software is developed here.. The system software is made using Visual Basic which helps to form graphical user interface i.e. the parameters can be displayed in forms of bar chart, table and graphical display. Also, it can print the reports of the parameters generated. The different environmental parameters received by the ground control PC are displayed in the manner as required on the LCD screen. The different parameters are the temperature, humidity, etc. The computer stores the parameters in the hard disk.

6.1. System Flow

1. Start
2. Initialize LCD
3. Display Project name "A"
4. Is serial Interrupt detected?
5. N → "A"
6. Y → Receive the frame and compare the slave ID
7. Is frame slave ID = μ C slave ID?
8. N → forward the frame on RF module → "A"
9. Y → Send the sensor readings (Temperature and level) to master via RF module

Note: The algorithm will be same for other slaves except the sensors change.

Master PC

1. Start
2. Wait 1 second
3. "A"
4. Send the request to the slave with slave ID and frame ID on RF module

5. Is serial Interrupt detected?
6. N → "A"
7. Y → Receive the frame and compare the slave ID
8. Is frame slave ID = PC slave ID?
9. N → Discard the frame → "A"
10. Y → display the sensor readings (Temperature and level) ON VB GUI "A"

7. Conclusion

In this application, as we are storing the values of the parameters in the PC, the hazards before they happen can be detected by the stored values.

The developed kit has fast execution speed. The sensors used for demonstration of concept are general. The resistive type temperature and humidity sensors show good sensitivity. The ZigBee communication is noise free. ZigBee and LPC2138 provide low power platform. More advanced version of controller like Cortex-M3 can be used for more speed of execution and extreme low power consumption. With use of sophisticated sensors, the system can work with more accuracy in real time. It can be modified in industrial monitoring as well.

There are many and varied applications for WSNs. To monitor data using WSN in commercial and industrial applications would be difficult and expensive using wired sensors. They could be deployed in wilderness areas, where they would remain for many years (monitoring some environmental variable) without the need to recharge/replace their power supplies. They could form a perimeter about a property and monitor the progression of intruders (passing information from one node to the next). There are a many uses for WSNs. Monitoring, tracking, and controlling includes typical application of WSNs. Habitat monitoring, object tracking, nuclear reactor controlling, fire detection, traffic monitoring are some of the specific applications. In some typical application, a WSN is scattered in a region where it is meant to collect data through its sensor node. The WSN-based controller has allowed a considerable decrease in the number of changes in the control action and made possible a study of the compromise between quantity of transmission and control performance. The level crossing sampling limit has presented a great influence on the event based control performance where, the system has provided promising results for the green house climate control problem.

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Author Profile



Shweta. S. Badgi received the B.E. degree in Electronics Engineering from Walchand Institute of Technology, Solapur in the year 2004. She is currently pursuing M.E (VLSI & ES) at Dr. D. Y. Patil College of Engineering. She is working as an Assistant Professor at Dr. D. Y. Patil Institute of Engineering and Technology, Amb-Talegaon, Pune.

N. A. Dawande is working as Principal at Dr. D. Y. Patil College of Engineering, Ambi-Talegaon, Pune. He received M.E in Electronics Telecommunication Engineering in 2005. M. S in Wireless Networks in 2008.