

Monitoring and Controlling in Food Storage System using Wireless Sensor Networks Based on Zigbee & Bluetooth Modules

Sandeep Kaushik¹, Charanjeet Singh²

¹M.tech pursuing, ECE department, DCRUST, Murthal, Sonapat, India, Kaushiksandeep26@gmail.com

²Assistant professor, ECE department, DCRUST, Murthal, Sonapat, India, dcrustcharanjeet@gmail.com



ABSTRACT

Wireless sensor networks have a strong impact all over the world over the wired networks due to the development of new standards and technologies from the last decades. Wireless sensor networks are used in a wide range of applications including remote Monitoring, health care, industrial automation or environmental monitoring. Each WSN may have specific objectives and application goals. Here our objective is to assure maximum quality and minimum spoilage of the stored food in food industry, by maintaining and monitoring of the temperature and humidity of the environment. Sensory data comes from temperature and humidity sensors of different locations, where food is stored and received at the receiver. WSN is formulated by a group of sensor nodes equipped with short-range communication capability. Every sensor node consists of at least a transceiver, a processing unit, a transducer and a power unit. New standards and technologies like Bluetooth (IEEE 802.15.1), Zigbee (IEEE 802.15.4), having a specific parameter of low power consumption, are used for short range wireless communications. This paper provides the implementation of monitoring and controlling of temperature and humidity in the food industry using Zigbee & Bluetooth modules and to check the performance of the network using both modules.

Key words: Bluetooth, Temperature sensor, Humidity sensor, Zigbee, PIC microcontroller

1. INTRODUCTION

Cold storage of fruits and vegetables was used extensively by our ancestors to keep food safe after the harvest season. In modern times, availability of fresh produce in the food industry has reduced the use of home storage. Often excess fruits and vegetables are kept in food industry, which cannot be consumed immediately but could store well. There is a need of maintaining the temperature and humidity of the environment, where the food is stored. It is necessary to monitor the temperature and humidity to assure maximum quality and minimum spoilage of the stored food in an effective way [1]. With the advent of low-power embedded systems and wireless networking, it is possible to implement in a reliable manner. The implementation of these networks is

based on Bluetooth and Zigbee both. The specific parameters and details of these two protocols are given below.

1.1 Bluetooth

Bluetooth, the IEEE 802.15.1 standard is based on a wireless radio technology used for short-range communication to eliminate cables connections for computer peripherals, like as mice, keyboards, joysticks, printers and electronic devices like mobile phones, PDAs. Other general characteristics of Bluetooth are: operates in star topology and transfer rate up to 3 Mbps in version 2.0 + EDR (Enhanced Data Rate), ratified in November 2004 [2]. Bluetooth is a low cost and low power wireless technology for connecting portable Bluetooth enabled devices to form short-range wireless ad hoc personal area networks (PANs). Bluetooth uses the unlicensed Industrial, Scientific, and Medical (ISM) band around the 2.4 GHz frequency range, with a transmitting power of 1 mW can reach a distance of range up to 10 meters, by increasing the transmitting power upto 100 mW, the range can reach up to 100 meters. The Bluetooth specification does not specify a protocol to form ad hoc Bluetooth networks. Piconet and scatternet are the two connectivity topologies are defined in Bluetooth. A Bluetooth piconet consists of a Bluetooth device serving as a master and one or more Bluetooth devices serving as slaves. Each piconet is defined by a frequency-hopping channel based on the address of the master. All communication devices are synchronized using the clock of the master in a piconet. Slaves can communicate only with their master in a point-to-point fashion. A scatternet can be formed by connecting two piconets through a common Bluetooth device (a gateway or bridge), the communication between master and slaves nodes is achieved using a TDD (Time Division Duplex) protocol [3].

1.2 Zigbee

Zigbee is a specification based on an IEEE 802.15 standard, known as wireless personal area networks (WPAN). The IEEE 802.15.4 standard and Zigbee protocol stack provides low cost, low data rate(less than 250 kbps) and low energy consumption .The low cost allows the technology to be widely deployed in wireless control and monitoring applications such as Home Automation, Healthcare Medical Monitoring, commercial and residential control, Agriculture and

Environmental Monitoring etc[4]. Wireless sensors networks make a particular Ad hoc network, integrated with active applications allowing control and help to decision for particular applications such as various monitoring and tracking applications and many others.

2. SYSTEM OVERVIEW

The whole system consists of two wireless sensor networks based on Zigbee and Bluetooth. The heart of the system is the microcontroller, which controls both of the networks by relay switching. A relay is connected with the microcontroller, when the relay is on, wireless sensor network based on Bluetooth works and when it is off, then the network based on Zigbee works. Different sensors like temperature and humidity sensors are used to measure the temperature and humidity of the environment. After measuring the temperature and humidity, the data is sent to the monitoring unit, where the data is recorded. If the temperature or the humidity of the environment increases from a particular point, then we can control the temperature or humidity wirelessly.

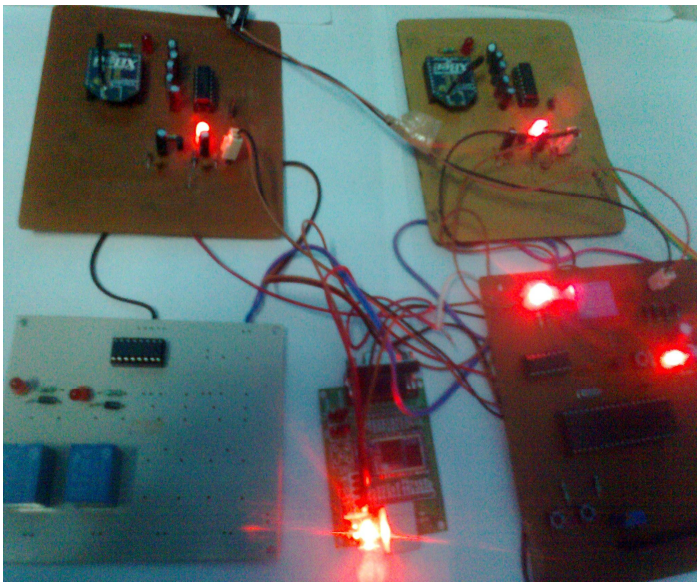


Figure 1: Hardware designing of wireless sensor networks

3. IMPLEMENTATION OF THE NETWORK USING ZIGBEE MODULE & BLUETOOTH MODULE

Zigbee wireless sensor nodes mainly consists the sensor unit, monitoring and controlling unit consists of microcontroller (MCU), XBee modules, Bluetooth module and other components. Micro-controller is responsible for collecting environmental information (such as temperature and humidity) and does analog to digital data conversion. Microcontroller is also responsible for controlling and managing the entire nodes. XBee and Bluetooth modules are responsible for the communication between different nodes.

Sensor unit is the basic unit of wireless sensor network. Sensor unit is used for sensing the environment temperature and humidity values, collecting information and converting to digital signals and monitoring unit is comprised of data acquisition module and data processing module. Data acquisition module receives the data from sensor unit and data processing module makes the decisions according to the environment conditions.

3.1 Sensor unit

A sensor unit basically consists of temperature and humidity sensors, which detects the temperature and humidity of the environment. The information being sensed by the sensors are the analog values, but the microcontroller works on digital values. The analog values are converted in digital values by the analog to digital convertor, which is built in pic microcontroller .Using the Zigbee and Bluetooth modules at the transmitting side, the pic microcontroller sends the data at the monitoring unit.

3.2 Monitoring unit

Zigbee and Bluetooth module at the monitoring unit is used for receiving the data sent from the sensor nodes. Data can be recorder at the monitoring unit. When, we use wireless sensor network based on Zigbee, the data can be recorded in computer using Zigbee and in Laptops having Bluetooth. Communication is performed between Zigbee module and Computer by RS232 serial communication. While using the network based on Bluetooth, the data can be recorded in laptops and android phones having Bluetooth modules. Before communication to be performed, it is necessary to pair the laptops and android phones with the Bluetooth modules at the sensor unit; otherwise the data would not be displayed at the monitoring side.

4. BASIC COMPONENTS USED

To make this system many electronics components are used, like as 2.4 GHz Zigbee modules, Bluetooth modules, pic microcontroller, temperature sensor, humidity sensor, RS232 serial communication, resistors, capacitors and diodes etc.

Brief introduction of some of the main components are given below

4.1 2.4 GHz Zigbee Modules

The Zigbee module used in this wireless sensor network is an XBee module built by, Digi International. Low cost and low power consumption are the main advantages of this module. The module provides reliable delivery of data between remote devices. The XBee module operate within the ISM 2.4 GHz frequency band and is compatible with XBee RS-232 Adapter , XBee RS-485 Adapter, XBee Analog I/O Adapter, XBee Digital I/O Adapter, XBee Sensor, XStick , Connect Port X

Gateways, XBee Wall Router and XBee USB Adapter. IEEE 802.15.4 standard stack, basis for Zigbee, allows a very reliable and simple communication between computers, microcontrollers and embedded systems etc. RS232 is used for serial communication between XBee module and PC. GHz XBee module can communicate both point to point and point to multipoint communication [5]. XBee module used in the WSN is shown in figure 2

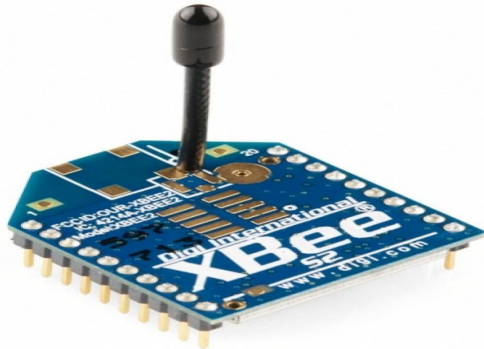


Figure 2: XBee S2 module

4.2 AUBTM-20 Bluetooth modules

AUBTM-20 is Bluetooth Core V2.0 compliant module. This module is designed to be embedded in a host system which requires cable replacement function. This module can interface with a host through the UART port. The module could both act a SPP master and a SPP slave. When the module is in master mode, it has the capability of searching all the working SPP slave devices around, but the host could select which SPP slave is to connect. In slave mode, SPP slave will listen for connection request from another SPP master device and could make the connection with it [6]. Bluetooth module used in the WSN is shown in figure 3



Figure 3: AUBTM-20 Bluetooth modules

4.3 Pic 16f877 microcontroller

The Pic16f877 microcontroller is RISC-based processor with an accumulator, having operating speed: DC - 20 MHz clock input. It has 8K x 14-bit words of Flash program memory, 368 bytes of data memory (RAM), 256 bytes of EEPROM data memory and eight A/D input channels. The MSSP module can operate in one of two modes: Serial Peripheral Interface (SPI), Inter-Integrated Circuit (I2C). The data receiving terminal of Zigbee XB_RX and data transmitting terminal XB_TX are cross connected to the microcontroller corresponding transmitter and receiver terminals Tx/D [7].

4.4 Temperature & Humidity Sensors

The temperature sensor used in this system for measuring the temperature is LM35. Its output voltage is linearly voltage to the Celsius temperature. The specifications of LM35 are linear output, low output impedance and precise inherent calibration. LM35 does not require any external calibration to provide typical accuracies of $\pm 0.25^{\circ}\text{C}$ at room temperature and $\pm 0.75^{\circ}\text{C}$ over a full -55 to $+150$ temperature range. Humidity sensor used in this system for measuring the humidity is HC201.

5. SOFTWARE USED

ISIS Schematic Capture and MPLAB IDE are the software used in these networks. ISIS Schematic Capture is used for PCB designing for the hardware and the MPLAB IDE is used for the programming and simulating of the circuit. ISIS Schematic Capture is a part of Proteus software. The circuit designing of WSN using Bluetooth & Zigbee modules in ISIS Schematic Capture is shown in figure 4.

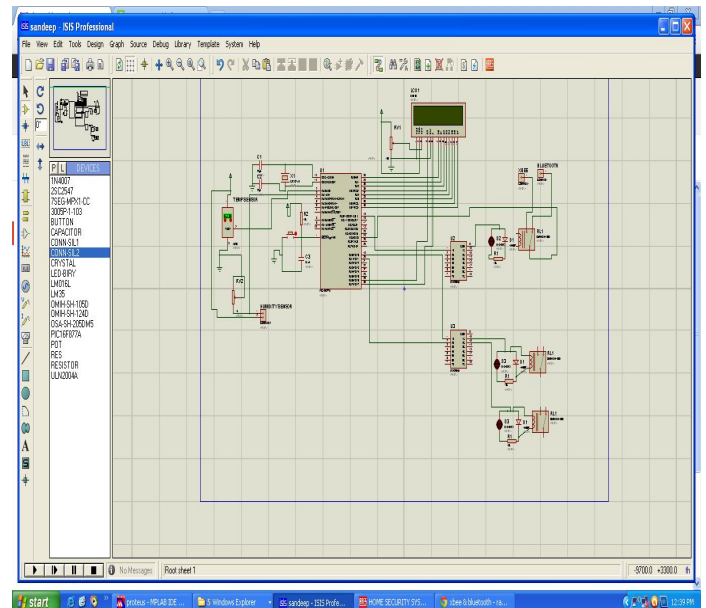


Figure 4: Circuit designing of wireless sensor network using Bluetooth & Zigbee modules in ISIS schematic capture Software

In MPLAB IDE, a single integrated Development Environment is used to develop code for embedded a microcontroller, that's why it is called an Integrated Development Environment (IDE). It is a software program that is used to develop applications for Microchip Microcontrollers.

Hyper terminal is software used to show the output of the environment, which is sent by the sensor unit using Bluetooth module. It is a terminal emulation program that supports communications in serial com ports, dial up modems and over TCP/IP networks. It has capabilities beyond making connections to other computers. It can transfer large files from a computer onto a portable computer using a serial port rather than requiring setting up a portable computer on a network. Temperature and humidity of an environment is recorded as shown in figure 5.

```

TEMP-043.0
humidity-008.0
TEMP-040.0
humidity-007.0
TEMP-038.0
humidity-007.0
TEMP-036.0
humidity-007.0
TEMP-035.0
humidity-007.0
TEMP-035.0
humidity-008.0
TEMP-034.0
humidity-009.0
TEMP-034.0
humidity-008.0
TEMP-033.0
humidity-008.0
TEMP-033.0
humidity-009.0
TEMP-033.0
humidity-008.0
TEMP-032.0
humidity-

```

Figure 5: Temperature and Humidity data recorded in laptop Using Hyper Terminal software

6. PERFORMACE COMPARISON OF BOTH THE NETWORKS

The performance of both the networks has also been studied. It was found that the range of the network having Bluetooth module is less, but the response time and data rate is fast as compare to the Zigbee network. The main advantages of Zigbee over Bluetooth is its low power consumption and high range of the network makes it better than the Bluetooth network.

6. APPLICATIONS

This system can also be used in other types of applications for monitoring and controlling, like as Home automation, Healthcare applications etc.

1. Home automation system - To balance the temperature and humidity of the environment of the house, the monitoring and controlling of the home environment can be done easily.

2. Health care applications – When a patient surgery is done, to avoid any reaction due to temperature and humidity, there is always a need of monitoring and controlling of the environment. This system is very effective in this case.

3. Semiconductor devices are also affected a lot due to high temperature variation, so in such conditions, there is requirement to control the temperature. This system can be used there.

7. CONCLUSION

The system aims is to establish monitoring and controlling platform in the food storage system based on Zigbee and Bluetooth and to find the more suitable wireless network for the food storage system. The Central monitoring unit can receive the monitoring data of sensor units and stores them in the database, and also can call and print that at any time. Both wireless standards have their own applications, advantages and drawbacks depending on the parameters, but especially Zigbee is more effective and economical as compared to Bluetooth .The proposed implementation shows that wireless sensor network based on Zigbee offers low power consumption and high range as compare to the network based on Bluetooth. It can be concluded that for the food storage system implementation using Zigbee is more suitable than Bluetooth.

REFERENCES

1. Pasquale Catalano, Flavio Fucci, Giovanna La Fianza and Ferruccio Giametta. **A System for Food Drying Using Humidity Control and Low Temperature**, *Agricultural Engineering International: the CIGRE journal*, Vol. X, January, 2008.
2. Kapil Bhoria and Harish Rohil. **Performance Analysis of IEEE 802.11b, 802.15.1 and 802.16a Standards**, *IJCST*, Vol. 3, Issue 1, Jan. - March 2012.
3. Jin-Shyan Lee, Yu-Wei Su and Chung-Chou Shen. **A Comparative Study of Wireless Protocols: Bluetooth, UWB, Zigbee, and Wi-Fi**, *The 33rd Annual Conference of the IEEE Industrial Electronics Society (IECON)*, Nov. 5-8, 2007, Taipei, Taiwan.
4. Ms.Dharmistha D. Vishwakarma. **IEEE 802.15.4 and Zigbee: A Conceptual Study**, *International Journal of Advanced Research in Computer and Communication Engineering*, Vol. 1, Issue 7, September 2012
5. XBee®/XBee-PRO® RF Modules, IEEE® 802.15.4 RF Modules by Digi International.
6. AUBTM-20 Bluetooth V2.0 Class 2 module Product datasheet.