A ZigBee based Smart Wireless Sensor Network for Monitoring an Agricultural Environment

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Abstract— This paper reports the design and development of a smart wireless sensor network (WSN) for an agricultural environment. Monitoring agricultural environments for various factors such as light, temperature and humidity along with other factors can be of significance. The sensor data is transmitted to network coordinator which is heart of the wireless personal area network. In the modern scenario wireless networks contains sensors as well as actuators. ZigBee is newly developed technology that works on IEEE standard 802.15.4, which can be used in the wireless sensor network (WSN). The low data rates, low power consumption, low cost are main features of ZigBee. WSN is composed of ZigBee coordinator (network coordinator), ZigBee router and ZigBee end device. The sensor nodes information in the network will be sent to the coordinator, the coordinator collects sensor data, stores the data in memory, process the data, and route the data to appropriate node**.**

Key words: WSN, ZigBee

I. INTRODUCTION

Provident Fund is the fund which is composed of the ZigBee is a typical wireless communication technology, which is widely used in wireless sensing networks. ZigBee wireless sensor network is widely used in military security, environment monitoring, and home automation. Various progressive wireless communication standards were developed and implemented into practice during the last decade. GSM, Wi-Fi and Bluetooth are well known amongst people in the modern society. These standards have penetrated into their daily routine with outstanding popularity. "An Internet of people" has become ordinary for everyone who wants to have everybody and everything within reach. Even though it seems that all peoples' wireless requirements have fulfilled, it turns on, that they lack of something like "an internet of things" especially in mainstream Home Automation (HA). As a new technology, in the practical application the advantage of the ZigBee wireless sensor network was not very ideal, especially in a large scale wireless Zigbee sensor network, because the coordinator processing ability is limited. In the large scale ZigBee wireless network the coordinator should deal with too much message, so some shortcomings come out, such as information time delay, data packet loss, and sensor node out of control. There are some algorithms that were proposed to improve the communication efficiency by the researchers, but that only aimed at the software aspects. A distributed processing design is proposed in this paper. The whole task of the network will be divided into two parts; one is about the network building, node joining, and data collecting; the other one is about data processing, network information conservation, and communicate with the host computer. The first part will be finished by the coordinator and the other one by another processor, which is connected with the coordinator by RS-232 interface. By this way the performance of the ZigBee wireless system improves a lot.

II. WIRELESS SENSOR NETWORK

A wireless sensor network is a collection of nodes. Each node consists of processing capability (one or more MCUs or DSP chips), multiple types of memory (program, data and flash memories), a RF transceiver, a power source (batteries), and accommodates various sensors and actuators [1]. The nodes communicate wirelessly and often self-organize after being deployed in an ad hoc fashion. A WSN is a distributed real-time system. Most past distributed systems research has assumed that the systems are wired, have unlimited power, are not real time, have a fixed set of resources, treat each node in the system as very important and are location independent. In contrast, for wireless sensor networks, the systems are wireless, have scarce power, are real-time, utilize sensors and actuators as interfaces, have dynamically changing sets of resources, aggregate behavior is important and location is critical. Many wireless sensor networks also utilize minimal capacity devices which places a further strain on the ability to use past solutions. Usually these devices are small and inexpensive, so that they can be produced and deployed in large numbers, and so their resources in terms of energy, memory, computational speed and bandwidth are severely constrained. There are different Sensors such as pressure, accelerometer, camera, thermal, microphone, etc. They monitor conditions at different locations, such as temperature, humidity, vehicular movement, lightning condition, pressure, soil makeup, noise levels, the presence or absence of certain kinds of objects, mechanical stress levels on attached objects,the current characteristics such as speed, direction and size of an object. Normally these Sensor nodes consist there components: sensing, processing and communicating. Wireless Sensor Networks (WSNs) are traditionally composed of multiple sensor nodes that sense environmental phenomena and generate sensor readings that are delivered, typically, through multi-hop paths, to a specific node (called the sink) for collection [2].

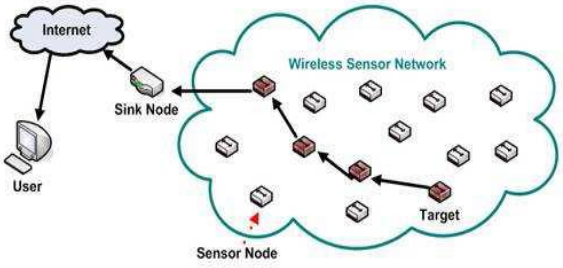

Fig. 1: Traditional Wireless Sensor Network

III. PROPOSED SYSTEM ARCHITECTURE

The architecture of proposed system has several types of nodes. It captures the physical phenomenon such as pressure, humidity, light intensity, temperature. The sensed data is transmitted to the ADC pin of microcontroller and then it is transmitted to ZigBee Rx pin through UART Tx pin.

Sensors are connected to port-A of MCU while LCD is connected to port-B. ZigBee module-1 is communicating to ZigBee module-2 (XB 24) via wireless radio link. The ZigBee module-2 is connected to PC via RS232 cable. The sensing data is plotted using MatLab and data is stored in HyperTerminal for future use.

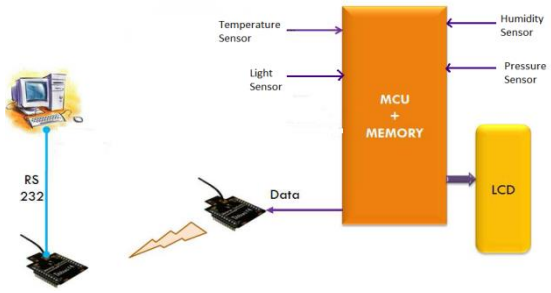

Fig. 2: Functional Block Diagram of System being Developed

Main sensors used are:

A. Temperature Sensor

The temperature sensor LM-35 is used to sense the environmental temperature. The Vout pin of LM-35 is connected to Vin pin-0 of ADC of MCU. The temperature reading of 8 bit stored inside MCU memory. The LM35 is precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. This will require a voltmeter to sense the temperature. Vout can be measured by voltmeter. The output voltage is converted to temperature by a simple conversion factor. The sensor has a sensitivity of 10mV/^{0}C. Hence conversion factor is the reciprocal, and that is 100^{0}C/V. The general equation used to convert output voltage to temperature is:

Temperature(^{0}C) = Vout * (100^{0}C/V)

So if Vout is 1V, then, Temperature = 100^{0}C. The output voltage varies linearly with temperature. Temperature reading is also displayed on LCD with the distance reading.

Fig. 3: LM 35

B. Light Sensor:

The light sensor LDR is used to sense light intensity. It is connected to the pin-1 of ADC of MCU.

LUX=500 V(out) /(50-10*V(out))

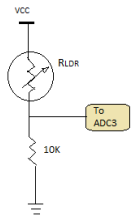

Fig. 4: Light Sensor

C. Humidity Sensor

Humidity Sensor HSM-20G is connected to the pin-2 of ADC of MCU. To use Humidity sensor users have to build a connector cable to connect the sensor to the PCB circuit. Connect 4-header to circuit so that (-) pin connects to GND, (+) pin connects to VCC and H pin is connects to microcontroller. Microcontroller's I/O pin needs to be set to ADC mode. The circuit in Figure 5 shows the circuit of humidity sensor.

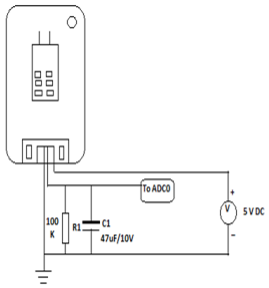

Fig. 5: Humidity Sensor

D. Pressure Sensor

The MPX 2010 pressure sensor is connected to pin-3 of ADC.

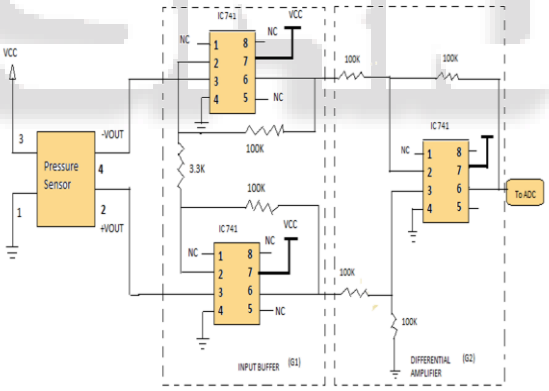

Fig. 6: Pressure Sensor

IV. ZIGBEEE MODULE

The XBee RF Modules are designed to operate within the ZigBee protocol and support the unique needs of low-cost, low-power wireless sensor networks. The modules require minimal power and provide reliable delivery of data between remote devices. The modules operate within the ISM 2.4 GHz frequency band. It operates over a range of 100- 200 meters [3]. Fig.7 shows the zigbee module.

Fig. 7: Zigbee series 1 module

X-CTU is a Windows-based application provided by Digi's. This program was designed to interact with the firmware files found on Digi's RF products and to provide a simple-to-use graphical user interface to them. X-CTU is designed to function with all Windows-based computers running Microsoft Windows 98 SE and above. When launched, four tabs across the top of the program can be seen in Fig.8. Each of these tabs has a different function.
The four tabs are:

A. PC Settings

This tab allows user to select the desired COM port and configure that port to fit the radios settings.

B. Range Test

This tab allows users to perform a range test between two radios.

C. Terminal

This allows access to the COM port of the computer with a terminal emulation program. This tab also allows the ability to access the radios' firmware using AT commands.

D. Modem Configuration

This tab allows the ability to program the radio' firmware settings via a graphical user interface. This tab also allows users the ability to change firmware versions [4].

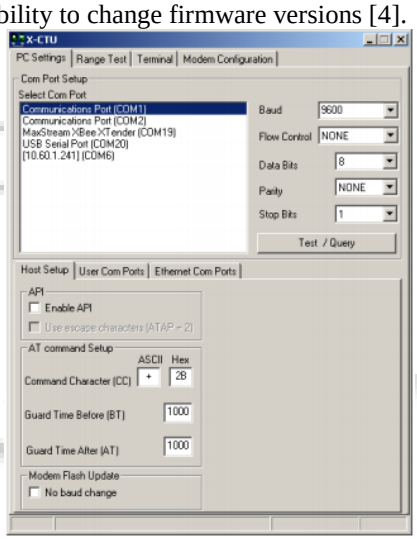

Fig. 8: X-CTU Setup

V. Application For Graphically Plotting And Saving Data

There are existing systems that could be used for plotting of data. However, it is seen that they were designed and aimed at mainly skilled and experienced operators. Therefore, new operators would often be required to undergo additional training in order to plot and save the data results from the system.

Therefore a simple but effective plotting application was designed to tackle this problem using MatLab. Six data from each sensor is transmitted at a time with delay of 1sec.

HyperTerminal is used for saving data for further use. Fig 10 shows how data is stored in HyperTerminal.

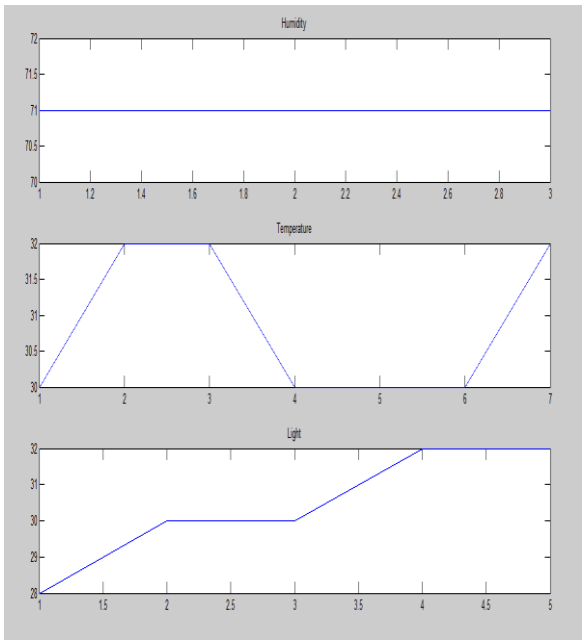

Fig. 9: Result from various sensor

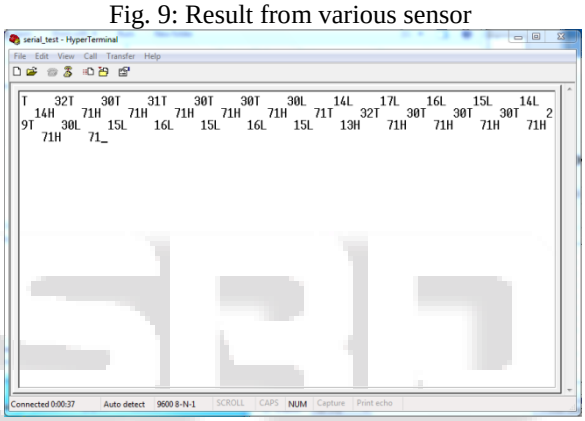

Fig. 10: Data stored in HyperTerminal

VI. Conclusion

The System is designed for the betterment of farmers. The uses of smart sensor based monitoring system for agriculture have been used to increase the yield of crop by monitoring the environmental conditions and providing information to observer. It would be a promising technology for the agriculturists all over the world in the present scenario of unpredicted weather conditions.

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