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- Sharma T., Kwatra, G. (2008) Effectiveness of Social Advertising: A Study of Selected Campaigns, Corporate Social Responsibility, Edited by David Crowther & Nicholas Capaldi, Ashgate Research Companion to Corporate Social Responsibility, Chapter 15, pp 287-303.

JOURNAL AND OTHER ARTICLES

- Schemenner, R.W., Huber, J.C. and Cook, R.L. (1987), "Geographic Differences and the Location of New Manufacturing Facilities," Journal of Urban Economics, Vol. 21, No. 1, pp. 83-104.

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WIRELESS MONITORING AND RECORDING OF ENVIRONMENTAL PARAMETERS BASED ON XBEE AND PIC

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ABSTRACT

To create a wireless environmental parameters recording system that can benefit from the continuous advancements being made in embedded microcontroller and communications technologies. Architecture for continuous wireless environmental monitoring has been designed, fabricated, and tested. The system consists of commercial-off-the-shelf (COTS) wireless-enabled module and components for communicating the temperature, humidity, light and gas parameters and a back-end database server and client application for logging and browsing the sensed parameters. In addition to browsing acquired sensed data, the client application enables the user to perform real time oscilloscope monitoring.

KEYWORDS
Graphical User Interface, mote, Wireless Sensor Network, XBee.

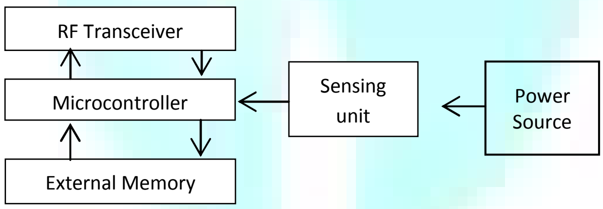
I. INTRODUCTION

Wireless Sensor Networks (WSN) has had a large increase in real applications during the last years. Its main advantage over other technologies is the actual economic development of its installation. Wireless sensor applications are not a real technology as a concept. The idea to implement an ad-hoc wireless network started at the beginning of the 70s [1]. The typical scenario was to set up a communication network in a battlefield, where no infrastructure is available. WSN are a trend of the last few years due to the advances made in the wireless communication, information technologies and electronics field [2]. The developments of low cost, low powered multifunctional sensors have received increasing attention from various industries [3]. WSN is a wireless network composed of autonomous and compact devices called sensor nodes or motes. A sensor network is designed to detect desired phenomena, then collect, process the data and transmit this information to users. Sensor nodes or motes in WSNs are small sized and are capable of sensing, gathering and processing data while communicating with other connected nodes in the network, via radio frequency (RF) channel. The sensor nodes scattered in a sensor field where each sensor nodes collects data and route the data back through a multi-hop hybrid wireless communications.

The design of the sensor network is influenced by factors including scalability, operating system, fault tolerance, sensor network topology, hardware constraints, transmission media, and power consumption [1]. The developments of low cost, low powered, multifunctional sensor have received increasing attention from various industries [3]. There are two kinds of sensor nodes in the network. One is the normal sensor node deployed to sense the phenomena. The other is a gateway node that interfaces sensor network to the external world. Sensor such as magnetometer, accelerometer, light and temperature are the type of sensors being used depending on the application.

As represented in Fig.1, the system architecture of a sensor node consists of a radio transceiver or optical as the communication unit, microcontroller for the processing, sensor as the sensing unit and D.C source as the power unit. The hardware device in the sensing unit may consist up to several sensors.

FIG 1: TYPICAL WIRELESS SENSOR NODE



The processing unit or control unit (CU) is responsible for the collecting and processing of the captured signal from the sensor unit. These signals are then transmitted to the network. It determines both energy consumption as well as computational capabilities of the sensor node. The power unit or D.C supplies power to the sensor node.

WSNs has been used in high-end application such as radiation and nuclear-threat detection systems, weapons sensors for ships, biomedical applications, habitat sensing and seismic monitoring [1]. Measurable changes are vibration, temperature, sound, motion, pollutants, humidity or pressure in environmental conditions [4], [5].The proposed system is the convergence of the sensing features of a sensor with the intelligence and decision making abilities of a micro system. They can be successfully deployed in many industrial applications such as maintenance, monitoring, control, security, etc. Free from the hassles of any ordinary sensor system, it has its advantages in terms of portability, reliability, flexibility and robustness.

The organization of the paper is as follows: In section 2, the proposed design is discussed that also presents the block diagram for our proposed system. In section 3, the hardware and software implementation along with flow diagram is discussed. In section 4, results are discussed. Finally, some conclusions are offered in section 5 and section 6 suggests future developments.

II.PROPOSED WORK

The main aim of this work is to design, develop and test environmental oriented WSNs for data acquisition, processing and visualization. PIC is the CU used while the transmitter utilizes XBee technology. Information sent by the sensors is processed by the PIC controller before it is transmitted to the base station. The PIC has been programmed to send the data periodically to the base station through the XBee module.

FIG 2. FLOW CHART OF PROJECT IMPLEMENTATION

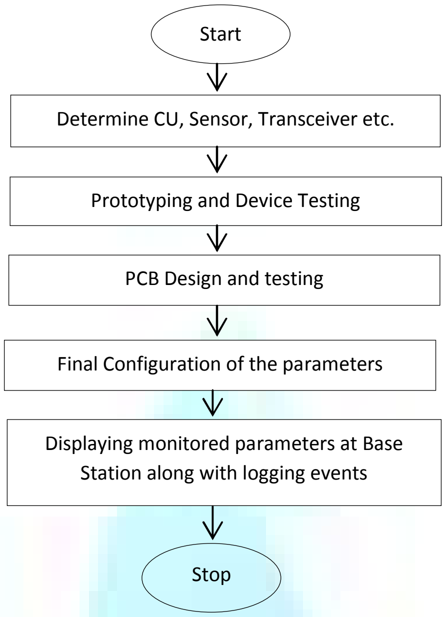
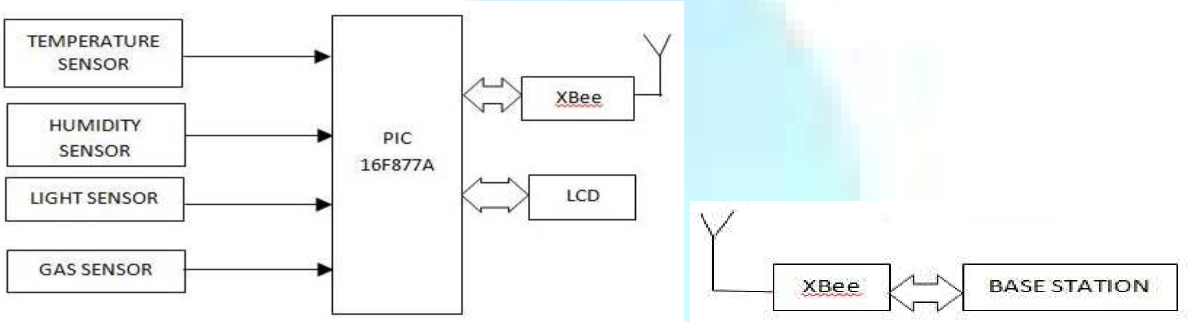


Fig.2 represents the processes carried out to produce the total system while Fig.3 is the total system block diagram consisting of temperature, humidity, light and gas sensor, and a wireless base station unit (WBSU) for creating a database as well as for visualizing events in WSN. One of the benefits of using XBee is the distance between the sensor node and the base station can exceed 100m for outdoor implementation. Therefore, it is very suitable for applications that involved outdoor monitoring and control.

FIG. 3: BLOCK DIAGRAM OF OVERALL SYSTEM.



A. SENSOR

Sensors are hardware device producing measurable response to change in physical condition such as temperature, gas etc. Sensor measures physical data by obtaining continual analog signal directly from the environment. This signal is then digitized by an Analog-to-digital converter (ADC) in the CU and is further processed. Characteristics or requirements of sensor node are it should be small in size, consume extremely low energy, operate in high volumetric densities, autonomous, and adaptive to the environment.

B. MICROCONTROLLER

As shown in Fig. 3, the microcontroller performs tasks, processes data and controls functionality of other components in the sensor node. Other alternatives are General purpose microprocessor, Application-specific integrated circuit (ASIC), Digital signal processors (DSP) or Field Programmable Gate Array (FPGA). Microcontrollers are the most suitable choice for sensor node due to flexibility in connecting to other devices, programmability and low power consumption as some parts of the controller are active while other parts can hibernate. Microprocessor on the other hand, consumes more power; therefore it is not a suitable choice for sensor node. This project shall not be utilizing DSP either since the required wireless communication is modest and simple.

C. IEEE 802.15.4 MODULES

XBee Modules were engineered to meet IEEE 802.15.4 standards 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 devices. The modules operate within the ISM 2.4 GHz frequency band and are pin-for-pin compatible with each other.

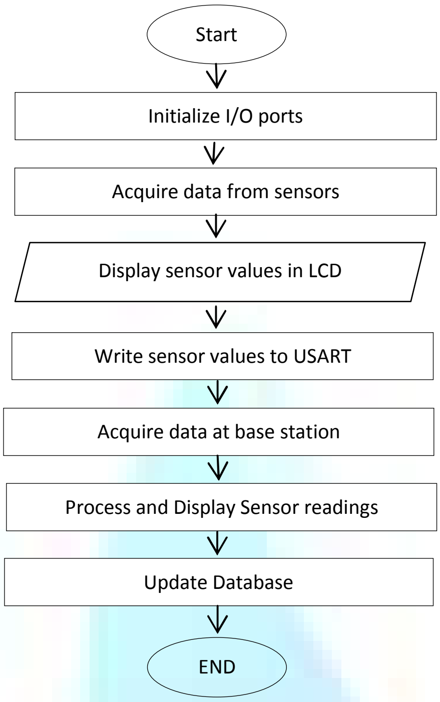
Sensor nodes make use of ISM band which gives free radio, huge spectrum allocation and global availability. The various choices of wireless transmission media are Radio Frequency, Optical communication (Laser) and Infrared. Laser requires less energy, but needs line-of-sight for communication and also sensitive to atmospheric conditions. Infrared like laser, needs no antenna but is limited in its broadcasting capacity. Radio Frequency (RF) based communication is the most relevant that fits to most of the WSN applications. WSN's use the communication frequencies between about 433 MHz and 2.435 GHz. XBee operates at 2.4GHz frequency with maximum data rate of 250kbps. This frequency band has the potential for large scale WSN application due to its high radio data rate. XBee product also utilizes 128 bit Advance Encryption Standard (AES) encryption for security purposes and therefore is suitable for various WSN applications.

FIG. 4: XBEE TRANSCEIVER

III. IMPLEMENTATION

The PIC was programmed using MikroC software that utilized C language. A program was developed to receive analog signal from the sensor circuit and display the output on LCD as well as send it to WBSU. The C program was converted into hex file before uploaded to the PIC using the PIC Pgm Program Developer.

FIG. 5: FLOWCHART OF TOTAL PROGRAM



This work proposes a portable wireless data acquisition system for temperature, humidity, light and gas in real time process dynamics. Process variables (like temperature, humidity etc) vary with time in certain applications and this variation should be recorded so that a control action can take place at a defined set point[5]. As the system monitors the environment under study, it senses temperature, toxic gas concentration, humidity and light. The temperature sensor senses the surrounding temperature and produces a corresponding output voltage of 10 mV per degree Celsius. Concurrently, the gas sensor produces an output voltage corresponding to the toxic gas concentration in the environment. The humidity sensor converts the relative humidity to output voltage. The light sensor produces an output voltage corresponding to the intensity of light.

The light sensor, temperature, humidity and gas sensor outputs are directly fed into the ADC pins of the PIC .The PIC 16F877A does the analog to digital conversion as well as processing of the sensor voltages according to the program stored in it. The LCD displays the current temperature, humidity, light, gas readings to enable on site monitoring.

The processed data is transmitted serially via the USART terminal of PIC to the XBEE. The XBEE transmits the data to the receiver end. At the receiver end, another XBEE is serially connected to the PC via serial port interfacing. The received data is processed and displayed on a front-end window in real time in both oscilloscope and GUI .A database is also created with date and time of occurrence of the events. Every time the data is transmitted and received it is entered into a log, that is smart logger is the convergence of the sensing features of a sensor with the intelligence and decision making abilities of a micro system.

Beside hardware development, the overall objective of this implementation is to set up a WSN topology consisting of several nodes for different position in a specified environment. However this paper shall present the communication results of a WSN with a single node to be tested in 3 different positions. Environment chosen were; outside of a building, an air-conditioned area and a room at room temperature. This is mainly intended for hardware functionality verification and operation ability in various environments.

FIG 6. SENSOR NODE (TRANSMITTING END)

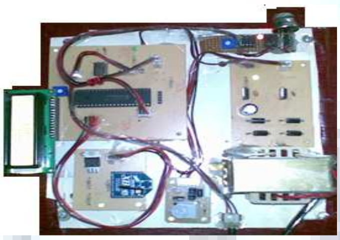
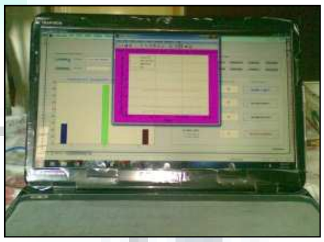


FIG 7. BASE STATION ((RECEIVING END)



IV. RESULTS AND DISCUSSION

Fig.8, 9 and 12 shows that the resultant output display at the base station screen. The results proved that the sensor node can sent sensed data from closed environment such as air conditioned room, to any room in the building and even from the outside of the building to the base station. These outputs are temperature, humidity, light and gas values, send by the wireless sensor node via the XBee transmitter to the base station receiver at the same and different environment. The results are displayed on the screen by using an interactive GUI shown in Fig 8.The GUI has options for analyzing data systematically in addition to real time visualization.

FIG. 8: GUI AT BASE STATION DEPICTING REAL TIME MONITORING OF ENVIRONMENTAL PARAMETERS

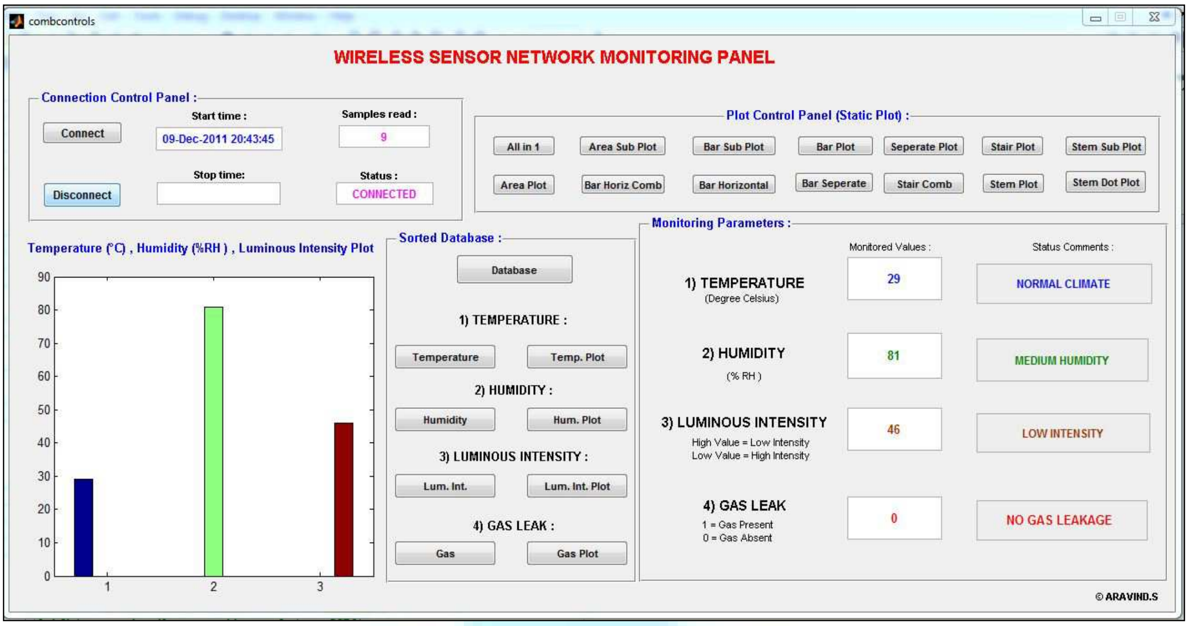
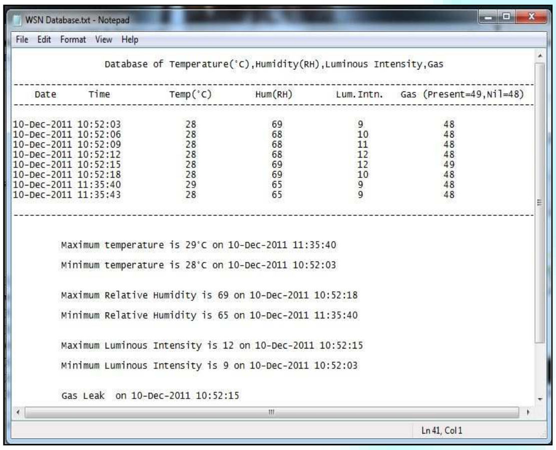


FIG 9: DATABASE AT WBSU


WSN Database.txt - Notepad

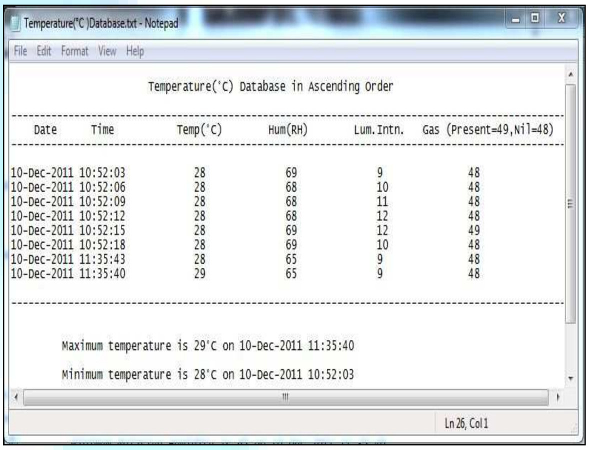
Database of Temperature('C),Humidity(RH),Luminous Intensity,Gas

Date	Time	Temp('C)	Hum(RH)	Lum.Intn.	Gas (Present=49,Nil=48)
10-Dec-2011	10:52:03	28	69	9	48
10-Dec-2011	10:52:06	28	68	10	48
10-Dec-2011	10:52:09	28	68	11	48
10-Dec-2011	10:52:12	28	68	12	48
10-Dec-2011	10:52:15	28	69	12	49
10-Dec-2011	10:52:18	28	69	10	48
10-Dec-2011	11:35:40	29	65	9	48
10-Dec-2011	11:35:43	28	65	9	48

Maximum temperature is 29'C on 10-Dec-2011 11:35:40
Minimum temperature is 28'C on 10-Dec-2011 10:52:03
Maximum Relative Humidity is 69 on 10-Dec-2011 10:52:18
Minimum Relative Humidity is 65 on 10-Dec-2011 11:35:40
Maximum Luminous Intensity is 12 on 10-Dec-2011 10:52:15
Minimum Luminous Intensity is 9 on 10-Dec-2011 10:52:03
Gas Leak on 10-Dec-2011 10:52:15

Ln 41, Col 1

FIG 10: SORTED DATABASE AT WBSU


Temperature(°C)Database.txt - Notepad

Temperature('C) Database in Ascending Order

Date	Time	Temp('C)	Hum(RH)	Lum.Intn.	Gas (Present=49,Nil=48)
10-Dec-2011	10:52:03	28	69	9	48
10-Dec-2011	10:52:06	28	68	10	48
10-Dec-2011	10:52:09	28	68	11	48
10-Dec-2011	10:52:12	28	68	12	48
10-Dec-2011	10:52:15	28	69	12	49
10-Dec-2011	10:52:18	28	69	10	48
10-Dec-2011	11:35:43	28	65	9	48
10-Dec-2011	11:35:40	29	65	9	48

Maximum temperature is 29'C on 10-Dec-2011 11:35:40
Minimum temperature is 28'C on 10-Dec-2011 10:52:03

Ln 26, Col 1

The main functions of proposed WSN system are:1)Ability to find maximum and minimum temperature, humidity and light intensity of a day, week, month, year etc. and store it in separate databases depicting the date and time of each sensor readings. 2) Oscilloscope real time display of the monitored parameters along with date and time at WBSU. 3) Ability to record and show the date and time of Gas leakage for a day, week, month, year in a separate database. 4) User specific selection of plot of acquired data from 14 different types of static plots. 5) To sound an alarm at base station on detecting gas leakage. These results proved that the sensor node can send data from any environment to a base station situated at a distance of even up to 100m continuously. Fig. 11 shows the oscilloscope application at the WBSU. The oscilloscope enables the four sensors to be monitored on time simultaneously. The interactive GUI enables simultaneous logging and oscilloscope application.

FIG. 11: OSCILLOSCOPE

V. CONCLUSION

This paper presented a wireless sensor network system based on XBee technology and microcontroller (PIC) for environmental monitoring. By exploring its system framework and technology characters the experiment has proved its feasibility. The sensor node has successfully transmitted sensor data to the base station located in the same environment. It is a preliminary work toward a better design of a PIC based wireless sensor node and a complete WSN. The system possesses low cost, low power, wider coverage, and especially the character of mobility.

VI. FUTURE DEVELOPMENT

Further development of more nodes should be highly considered. With the success of the development of this sensor node, hardware duplication could be carried to produce several nodes. With more number of nodes, the feasibility of the simulated WSN system developed earlier can be proven. The future scope of this work is: It can be used to make a network of clusters consisting of sensors in real time control applications. It is compatible with different network protocols. A memory database can be built by using on chip memory as well as remotely connected PC through wireless link. The system is flexible to change the control algorithms like PID control algorithm.

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