Zigbee Based Air Pollution Monitoring and Control System using WSN

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Abstract

Air pollution is an important environmental issue that has a direct effect on human health and ecological balance. The description of physical setup, the sensor node hardware and software architecture for "anytime anywhere" monitoring and management of pollution data is done through a single MATLAB-based graphical user interface. The proposed research work presents practical issues in the integration of sensors, actual power consumption rates and develops a practical hierarchical routing methodology. We need an accurate air pollution monitoring system that is light weighted, easy to handle and can monitor a wide assortment of air pollutants (CO, NO_2, and CO_2) inside motor vehicles. Zig bee wireless standard is chosen as a communication protocol. Hardware components like microcontroller, sensors (CO, NO_2, CO_2, humidity and temperature) and low-power radios-make up a sensor node. The proposed hardware is also having a serial port which is used to send the measured data from Zig bee based sensor network to the nearby computer. With the help of sensor network, data from a large area can be collected and can be processed out on MATLAB. MATLAB shows better performance for numeric computation as compared to web pages and shows better graphical representation as compare to other platforms.

Keywords — *Real-time monitoring, hierarchical routing, Zig Bee, pollution sensors.*

I. INTRODUCTION

In this current generation, air pollution [1] is one of the dangerous problems in human society. This is a worldwide faced problem. The ever increasing levels of carbon dioxide in the atmosphere, is leading to the temperature rise. We need an accurate air pollution monitoring system that is light in weight, easy to handle and can monitor a wide assortment of air pollutants (CO, NO_2, and CO_2) [2] emitted from motor vehicles. It ought to be sensitive enough to rapidly distinguish concentration levels of air pollutants such as Carbon Dioxide within the briefest time conceivable. Sensor module, likewise, needs to record barometrical readings like temperature, pressure, humidity and so on. The sensor module needs to be sturdy and equipped with batteries that can be easily charged using portable adapters or chargers like the ones used in car chargers. It needs to have either Bluetooth or wireless communication like X-bee, energy efficient RF model which is capable of communicating live readings to a remote device and wireless sensor networks (WSN).

II. SENSOR NETWORK ARCHITECTURE

The basic block diagram of a wireless sensor node is presented in Figure 1. It shows four basic components: a sensing unit, a controlling and processing unit, a transceiver or communicating unit and a battery power unit. There can be application dependent extra components such as area locator, mobilizer and power generator.

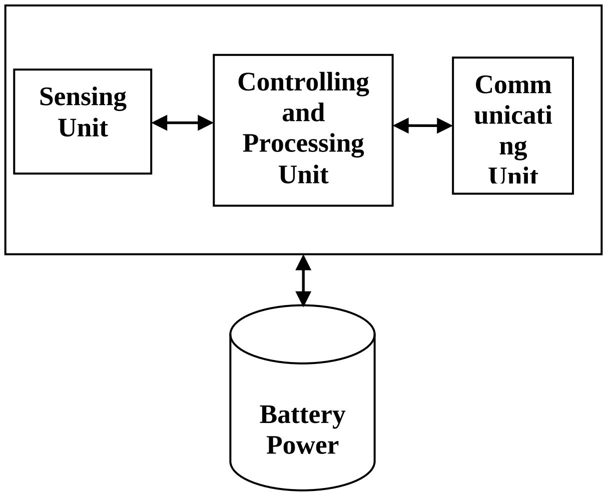


Fig.1. Sensor Network Architecture

A. Sensing Unit

Sensing units are typically composed of two subunits: Sensors and ADCs (Analog to Digital Converter). Sensor is a device which is used to convert physical phenomena to electrical signals. Sensors can be further classified as either analog or digital sensors [4]. There exists a choice of sensors that measure environmental parameters such as temperature, humidity, intensity of light, sounds, magnetic fields, images, etc. The analog signals produced by the sensors based on their sensing phenomenon are then converted to digital signals by the ADC and then fed into the next processing unit.

B. Controlling and Processing Unit

The processing unit mainly gives intelligence to the sensor node. The processing unit consists of a microcontroller, which is responsible for the controlling of sensors, complete execution of communication protocols and processing of signal algorithms on the gathered sensor data. Commonly known microcontroller are Atmel's AVR microcontroller (µC), Intel's Strong ARM microcontroller, and Arduino microcontroller [3]. In common, four main states of processor can be identified in any microprocessor *as Idle, Sleep, off and Active*.

C. Communicating or Transceiver Unit

The radio allows wireless communication with sensor nodes and also the outside world. It consists of one short vary radio that typically features a channel at low rate and operates at unauthorized bands of 868-870 MHz, 902-928 MHz or close to 2.4 GHz.

There are several factors that have an effect on the ability consumption characteristics of radio, such as the kind of modulation theme used, data rate, sending power and duty cycle. Just like microcontrollers, transceivers may be operated in: Idle, Transmit, Receive and Sleep modes. A very important conclusion determined within the case of most of the radios is working in idle mode results considerably in high quantity of power consumption, some adequate the ability consumed within the Receive mode. Thus, it's notably vital to completely shut down the radio instead of setting it to the idle mode once it has stopped sending or receiving information, owing to the high battery power consumption. Another vital influencing issue is that because the radio's operational mode changes the transient activity within the radio it causes a major quantity of power dissipation.

D. Battery Power Unit

The battery provides power to the whole sensor node. The amount of power dissipated from a battery ought to be rigorously monitored. Moreover, sensors should have an extended period of time from months to years, since replacement of battery isn't a simple choice for networks with 1000s of physically embedded nodes. This causes energy consumption to be one amongst the foremost necessary factors in determinative sensor node lifetime.

III. CIRCUIT FLOW AND PROGRAMMING ALGORITHMS

A. Circuit Flow

The circuit is shown below. P89C55RD2-8051 controller is used to process all the events. Multiplexer is used which connects all the sensors (CO_2, Temperature and Humidity) and ZigBee to the controller one at a time. Max-232 is used to convert RS-232 logic to TTL logic. Clock is provided to provide time span about which values from the following sensors will be taken. EEPROM is used for storage of data coming from sensors.

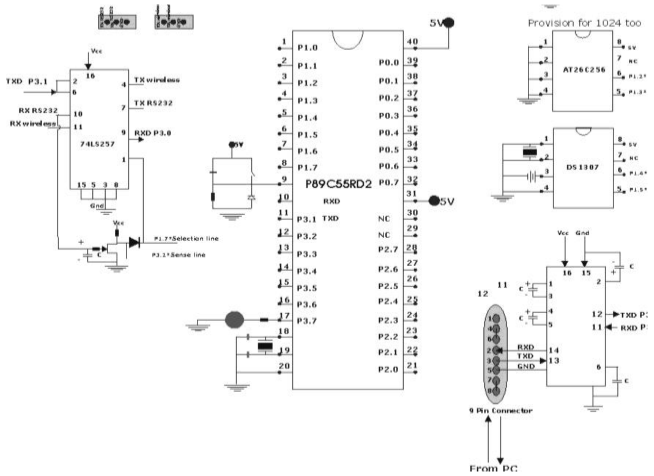


Fig. 2. Circuit Diagram

B. Programming Algorithm

The programming algorithm is shown in the form of flow chart.

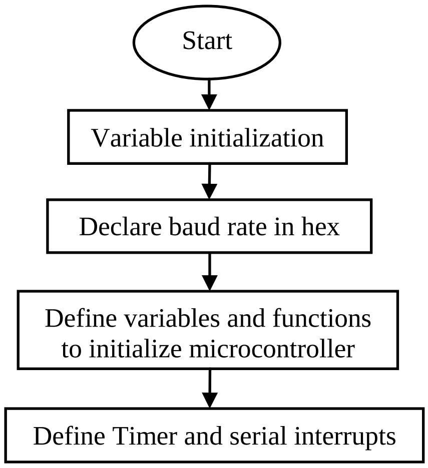
IV. SIMULATION AND RESULT

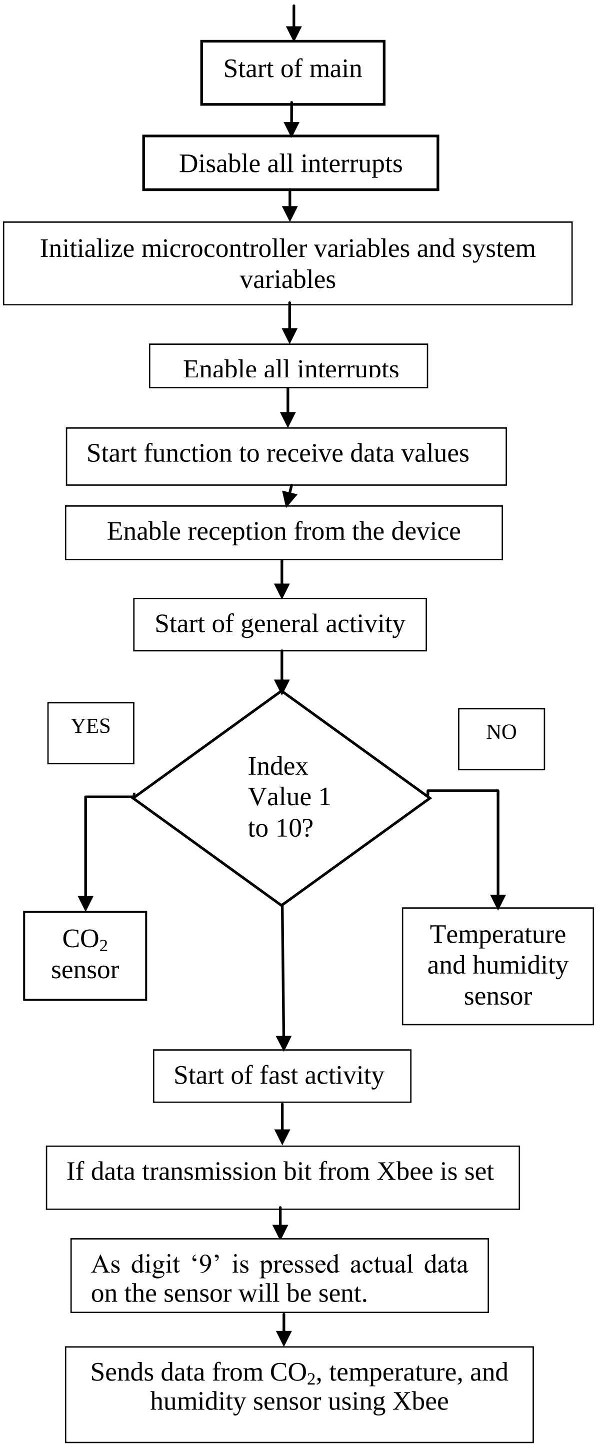
A. Simulation

This section describes about simulation and result analysis. In this section, the result of the proposed method for air pollution monitoring system is shown. For simulation of the proposed method, MATLAB R2013b (7.14.0.783) software is used. Basic configuration of our system is Manufacturer: DELL Processor : Intel(R) Core(TM) i5-4210U CPU @ 1.70 GHz 1.70 GHz with 4.00 GB (2.64 GB usable) RAM : System type: 64-bit Operating System.

B. Result Analysis

A Graphical User Interface with the help of MATLAB software to graphically analyze the serial data from XBEE COORDINATOR is used. This GUI is used to measure the air pollution monitoring of proposed system. It shows the current value of multiple sensors such as Co_2 sensor, temperature sensor and humidity sensor with respect to time.





C. Data wise Sensors Dataset Values

In the below table different sensor values are shown on MS office data base. Wireless sensor network sends the sensor values to the server. These values are stored in the Microsoft office data base. These values are used to analysis the pollution level of sensor network area.

The table 1 shows the sensor values of CO_2, Temperature, humidity, log time and log date of different days at different time in tabular form.

Log Date	Log Time	Temperature	Humidity	CO_2
1/4/2017	2:04:00 PM	38	25	4800
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1/4/2017	2:04:00 PM	38	25	4800
1/4/2017	2:04:00 PM	38	25	4800
1/4/2017	2:05:00 PM	38	25	4800
1/4/2017	2:05:00 PM	38	25	4800
5/4/2017	12:43:00 PM	37	27	4800
5/4/2017	12:43:00 PM	37	27	4800
5/4/2017	12:44:00 PM	37	27	4800
5/4/2017	12:44:00 PM	37	27	4800
5/1/2017	12:44:00 PM	37	27	4800
5/4/2017	12:44:00 PM	37	27	4800
10/4/2017	5:13:00 PM	33	30	4800
10/4/2017	5:13:00 PM	33	30	4800
10/4/2017	5:13:00 PM	33	30	4800
10/4/2017	5:13:00 PM	33	30	4800
10/4/2017	5:13:00 PM	33	30	4800
10/4/2017	5:13:00 PM	33	30	4800

Table I Sensor Data Output

Manual Mode Operation

S. No.	Sensor Value	Max	Min	Average
1.	CO_2	800 PPM	100 PPM	350 PPM
2.	Temperature	40^0C	28^0C	33^0C
3.	Humidity	90	20	40

The temperature in the month of April is 33^0C that is close to safe side. In general, April month contains 30^0C to 35^0C; similarly Humidity of the April month is 40.

D. Result Analysis of Output

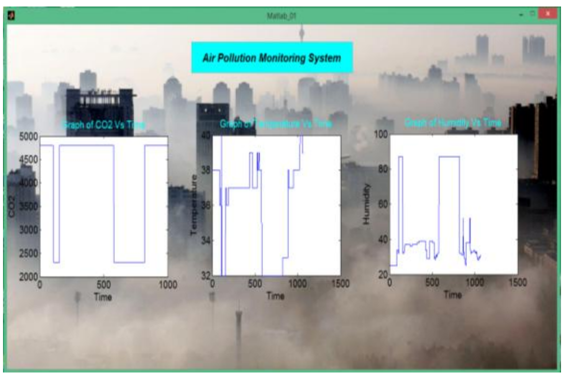

Fig. 3. Final Output of Sensors Data in the graphical form

Above figure shows the graphical output of the sensor data. In the first graph CO_2 v/s time shows pollution of CO_2 in PPM values with respect to time.

Similarly second graph shows the temperature v/s time and third graph shows humidity v/s time.

E. Effect on Health CO_2

	Health Effect CO_2
250-350 ppm	Normal background concentration in outdoor ambient air
350-900 ppm	Concentrations typical of occupied indoor spaces with good air exchange
1,000-2,000ppm	Complaints of drowsiness and poor air.
2,000-5,000 ppm	Headaches, sleepiness and stagnant, stale, stuffy air. Poor concentration, loss of attention, increased heart rate and slight nausea may also be present.
>40,000 ppm	Exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma, even death.

F. Health Effects of CO

	Health Effect CO
9 ppm	CO Max prolonged exposure (ASHRAE standard)
35 ppm	CO Max exposure for 8 hour work day (OSHA)
800 ppm	CO Death within 2 to 3 hours
12,800 ppm	CO Death within 1 to 3 minutes

G. Health Effects of NO_2

	Health Effects of NO_2
<0.1 PPM (Good)	Should have minimal health effects or occupant complaints.
0.1 to < 5 PPM (Marginal)	Could produce some negative health effects among vulnerable populations, including asthma and other respiratory problems.
5 PPM (Poor)	Likely to cause serious health problems and discomfort among population.

V. FUTURE SCOPE

Design and development of a sensor can be done which can single handedly measure different gases. Each mode of operation will measure different gas with respect to its wavelength.

Mode	Wavelength(µm)-Band interval(cm^{-1})	Gas
Mode 0	4.3 – (2000-2400)	CO_2
Mode 1	4.5 – (2100-2300)	NO_2
Mode 2	4.67 – (2000-2300)	CO

VI. CONCLUSION

This work describes the operation and application of a ZigBee based Air Pollution Monitoring and Control System Using WSN considering a low power consumption operation, a non-invasive installation, high connectivity range and computational capacity. Each sensor node is employed with an 8-bit microcontroller, sensors and a Zigbee module. Thus the resulting network monitors temperature, humidity and CO_2 data for a long time interval in an actual real time environment. The project also considers the development of a network connectivity, based on controller which is able to operate in unpredictable and dynamic environment. To deal with Smart Cities challenges, a cost-effective system is presented here. In future, we are looking to support the IEEE 802.15.4 protocol to deal with more complex WSN mesh network in the urban environments and better communication management using the MHz radio frequency range.

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