WSN BASED AIR POLLUTION MONITORING SYSTEM

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Abstract : Sensor networks have presently been an active research area mainly because of the significance of their applications. This project proposes to implement wireless sensor networks based Air pollution monitoring. RSPM (Respirable Suspended Participate Matter), Carbon Dioxide ($CO2$) and Nitrogen Dioxide ($NO2$) from the air are monitored as these gases determine the level of pollution. The use of MQ-6, MQ-135 sensors enabled us to monitor the Carbon Dioxide and Nitrogen Dioxide levels in the atmosphere. Also temperature and humidity is monitored using DHT11 sensor. The Atmega processor is used as the prominent platform for interfacing those sensors and the sensed data is processed wirelessly through Zigbee modules (Xbee S2C). The data hence received from the sensor device is simultaneously stored in a system as a help for a future reference in the levels of contamination. Thus with the help of the collected data, proper precautions can be taken to minimize the pollution levels in the air thus making human life sustainable.

I. Introduction

Air pollution is considered to be one of the most important factors determining the quality of life as well as health of the increasing urban population of industrial societies. In most urban places, air pollution is caused by emissions from mediums like power plants, cars and trucks and several manufacturing processes. Hence, when gases and particles from these polluting activities accumulate in the air in high concentrations, they become harmful for both human health as well as the environment. To add on, terrain along with meteorological conditions aggravate the air quality issues in the area. Although the national trend is encouraging better outdoor air quality, there are some urban areas in which unfortunately no improvement has taken place. Concentrations of outdoor air pollutants vary from day-to-day. In fact it also varies during the course of a day.
For the purpose of health protection, the public must receive timely information about air quality and other factors (e.g. weather conditions) that influence it. When the level of pollutant concentrations are high, access to air quality forecasts enables residents to reduce their exposure. This proves to be important particularly to people who are sensitive to certain pollutants causing harmful effects. For example, people with asthma may be sensitive to ground level ozone and sulphur dioxide. The study has been undertaken with major motivation behind our study being the development of the system so as to provide aid to the government in order to devise an indexing system to categorize air pollution in India. The project is to build an air pollution monitoring system; hence a detection system has been designed in this project for multiple information of environment. This project has been built for low cost, quick response, low maintenance, keeping in mind the ability to produce continuous measurements. The main goal of this project revolves around the efforts to monitor the air pollution, hazardous gases and mainly increase awareness about pollution by using air pollution monitoring system. Currently, the air quality control in almost all industrial hubs in our country is based on taking samples one or sometimes a day, thus showing that there is no information about time distribution and intensity of polluted materials during day. This happens to be the main disadvantage of such a system. Presently in the area, there are two methods which are used to monitor air pollution. One is passive sampling (non automatic), while the other is continuous online monitoring (automatic). The advantage of the passive sampling method is that the monitor equipment is simple and not too expensive, however it can only get on-site monitoring parameters for a certain period, real-time values cannot be provided. Meanwhile, the results of monitoring effect by the man factor largely and it will lead to serious health damage of the man who is monitoring in the site of high concentration of harmful substances.

The procedure of continuous monitoring method involves: use sensors to determine the parameters, transmit the sensed data to the control center by wired or wireless network. The wired way usually uses either public telephone network, or fiber-optic way for the realization of data transmission. At present, the wireless mode used in air pollution monitoring system includes GSM, GPRS, etc. But these modes prove to be highly costly not only in installation but also maintenance, and complexity. These days, Wireless sensor network has rapidly evolved from past years. From military and industrial controls, its advantages include the liability, simplicity and less expensive. Due to these advantages, it is now being applied in environmental monitoring. In air pollution monitor applications, we have developed a WSN based air pollution monitoring system using ZigBee networks for City. It emphasis on the implementation of air pollution monitoring system, and developing an integrated wireless sensor board which employs $CO2$, $NO2$, temperature, humidity sensor, atmega micro-controller, database server and a ZigBee module.

A. Objectives of the Study

The objective of this project includes designing, developing and testing an Atmega micro-controller and ZIGBEE Technology based system to monitor the air pollution. For wireless communication we used ZIGBEE modules. ZIGBEE wireless sensor network (WSN) is build for continuously monitoring the quality of air. This study helps in developing the constructive and optimizing technology of the wireless sensor network based on ZIGBEE. Intelligent node of wireless sensor network with functions such as signal acquisition, data processing and data transmission is also developed. The receiver is connected with LCD to display the data.

- It is Atmega 328 microcontroller based air pollution monitoring system.
- For monitoring the air pollution Temperature and Humidity sensors DHT11, Hydrogen or LPG sensor MQ-6, Nitrogen Dioxide sensorMQ-135 are used.
- ZIGBEE modules (Xbee S2C) are used for wireless data transmission.
- Transmission range is 60m.
- Operating frequency of ZIGBEE is 2.4 GHz frequency.
- Maximum data rate 250kbps.

B. Design steps for Methodology

The following steps to be followed to achieve the specified objectives are:

1. Review of literature survey.
2. Familiarization with the WSN technique and ZIGBEE modules.
3. Interfacing of all sensors with the microcontroller and display it on LCD.
4. Configuration of the WSN and interfacing it with the sensor
5. Collect air pollution readings from a region of interest.
6. Use of appropriate data aggregation to reduce the power consumption during transmission of large amount of data between the nodes.
7. Collect data and send them to the co-coordinator.
8. Display the values on the LCD.

II. Implementation of WSN with ZIGBEE

A. Wireless Sensor Node

A collection of nodes is called a wireless sensor network. Each node comprises 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. The nodes not only communicate wirelessly but also often self-organize after being deployed in an ad-hoc fashion. A WSN is a distributed real time system. Most of the past distributed research systems have 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 extremely important and are location independent. However in contrast, for wireless sensor networks, the systems are wireless, they have less power, are real-time, utilize sensors and actuators as interfaces, have dynamically changing sets of resources, aggregate behavior is important and the location is critical. Many wireless sensor networks also utilize minimal capacity devices which places a further strain on the ability to use past solutions. Mostly these devices are small as well as inexpensive, so that they can be produced and deployed in large numbers; hence their resources not only in terms of energy, but also memory, computational speed and bandwidth are severely constrained. There are different Sensors such as pressure, accelerometer, camera, thermal, microphone, etc. These 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 comprise of three components namely-sensing, processing and communicating. [2]

Wireless Sensor Networks (WSNs) are traditionally composed of multiple sensor nodes. These sense environmental phenomena as well as generate sensor readings that are delivered, most typically, through multihop paths, to a specific node (called the sink) for collection.

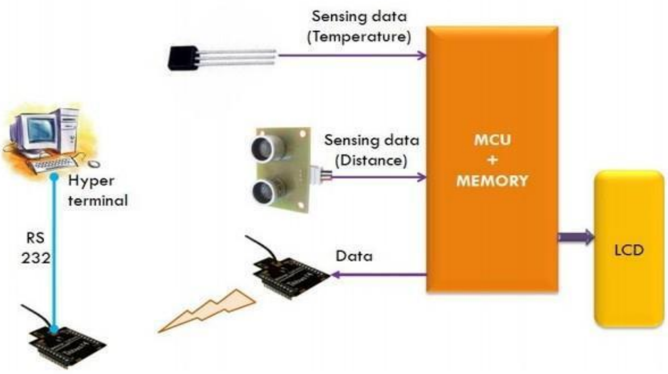

Figure 2.1. WSN Block Diagram

B. Sensor and Sensor Node

Sensor can be defined as a device that receives and responds to a signal or stimulus. It is generally an element that senses a variation in input energy which further produces a variation in another or same form of energy. A sensor (called detector as well) can also be defined as a converter that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. For example thermocouple converts temperature to an output voltage which can be read by a voltmeter. For accuracy, most sensors are calibrated against known standards. A sensor is a device which along with receiving, responds to a signal when touched. It is the sensors sensitivity which indicates how much the sensors output changes when the measured quantity in question changes. Sensors that measure very small changes must have very high sensitivities. Sensors need to be designed in such a way so as to have a small effect on what is measured; making the sensor smaller often improves this and may introduce other advantages as well. Technological progress allows many more sensors to be manufactured on a microscopic scale as micro sensors using the MEMS technology. In most cases, a micro sensor reaches a significantly higher speed and sensitivity compared to macroscopic approaches. [1]

The low cost sensors are densely deployed in WSN, thus enabling them to collect environmental data. The use of sensors and actuators in WSN can help control and monitor the environment. Due to their inexpensive nature and ad-hoc method of deployment, the sensor nodes have various energy and computational constraints.

Recently a research has been developed at energy efficient routing. The sensor nodes are small and distributed and these are capable of local processing along with wireless communication. However, each sensor node is capable of only a limited amount of processing. But they have the ability to measure a given physical environment in great detail if coordinated with the information from a large number of other nodes. Thus, a sensor network can be described as a collection of sensor nodes which co-ordinate to perform some specific action. However, unlike the traditional networks, sensor networks depend on dense deployment and co-ordination to carry out their tasks.[2] The multiple sensor nodes are required to overcome environmental obstacles like obstructions, line of sight constraints etc. The environment to be monitored has an ad-hoc infrastructure for communication. Another requirement for sensor networks would be distributed processing capability because communication is a major consumer of energy

III. Project Description

A. Hardware Architecture

The designed system is used by integrating the following hardware modules shown. As the figure shows, the system uses an ATMEGA 328 microcontroller integrated with a sensor array. The hardware unit is also connected to a ZigBee-Module. Each of these components used are described in the following section.

B. ATMEGA LM 328 Microcontroller

The ATMEGA 328 microcontroller is the main component of a pollution detection unit. The microcontroller provides communication to the ZigBee modem and ZigBee receiver and a parallel connection to the gas sensors. The connection between the gas sensors and the ATMEGA 328 microcontroller cannot be made directly due to the very small output voltages given by the sensors (mA).This problem is resolved by using auxiliary electronic circuits for signal conversion like OA (Operational Amplifiers) and transistors. [4]

C. ZigBee Modules

In this proposed project, two types ZigBee modules are used to organize a network for air pollution monitoring system. The network is controlled by devices called the ZigBee coordinator modem (ZCM). The ZCMs are responsible for collection of data and maintaining the other devices on the network and all other devices, known as ZigBee end devices (ZED), directly communicate with the ZCM.[8] The ZigBee module is a hardware platform of wireless device. The modules uses the basic function of Physical and MAC layer, such as transmit and receive, modulation and demodulation, channel and power control. They operate at a frequency of 2.4GHz ISM band wireless communication.[4] The modules include a digital direct sequence spread spectrum base band modem and an it gives an effective data rate of 250 kbps. They employ the EM2420 2.4GHz radio frequency transceiver. They also exhibit a nominal transmit of -1.5dBm and a receive sensitivity of -92dBm. When powered at 3.0V, the modules draws 31.0mA in transmit mode and 28mA in receive mode. When the entire module is in sleep mode, the current draw is reduced to approximately 10uA.

D. Sensors Array

The sensor array consists of two air pollutions sensors including Carbon Dioxide (CO_2) and Nitrogen Dioxide (NO_2).The resolution of these sensors is sufficient for pollution monitoring. Each of the above sensors has a linear current output in the range of 4 mA and 20 mA. The 4 mA output corresponds to zero-level gas and the 20 mA corresponds to the maximum gas level.[3] A simple signal conditioning circuit is designed to convert the 4 mA and 20 mA range into 05 V to be compatible with the voltage range of the built-in analog to digital converter in the ATMEGA 328 microcontroller.

IV. Flow chart

A. Transmitter Side

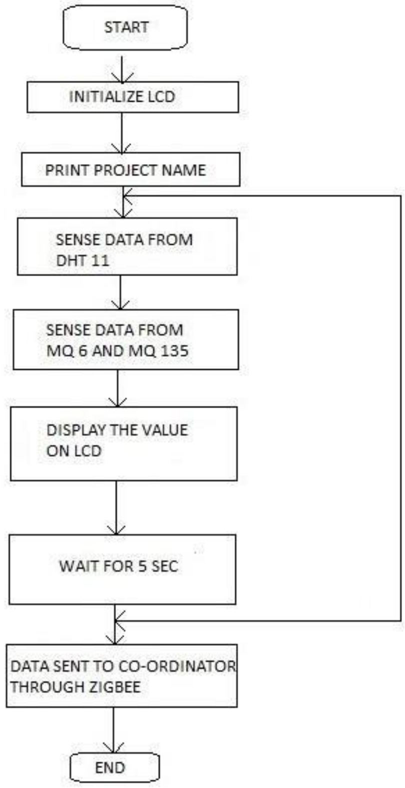

Figure 4.1. Transmitter Process Flow

As soon as we start the kit it will start collecting data from the sensors connected. The analog sensor data will be converted into digital form and simultaneously compared with predefined reference values which determine the threshold. As soon as the sensors output crosses the threshold values the microcontroller will transmit the data through Zigbee towards the receiver. If the sensed value does not cross the threshold values it will wait for 15 minutes and check the value again. In this way we are saving the data rate. Refer figure 4.1 for transmitter process flow diagram.

B. Receiver Side

Just after the kit is started it will initialize the LCD. It will continuously display the project name. On the other side the microcontroller will check whether there is any reception of the data. As soon as the data is received it will display it on the LCD. The data will be displayed differently for CO2 and NO2. It will simultaneously check for the fresh data reception. Refer figure 4.2 for detailed description of the receiver process flow diagram.

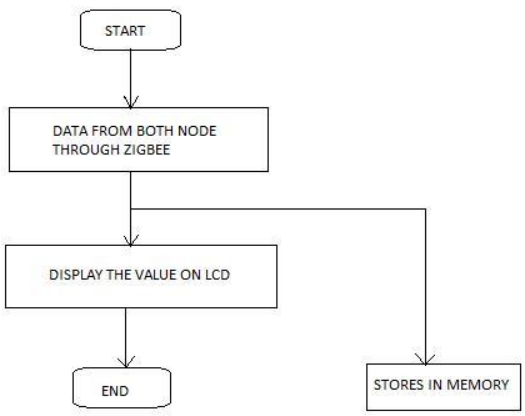

Figure 4.2: Receiver Process Flow

V. Result

Real time temperature and humidity was recorded several times a day with an interval of 3 hours between them in an indoor room. Similarly we can record data from the second node which can be kept in some other area. Readings taken are shown in below table.

Table 5.1. Results

Time	Temperature (Celsius)	Humidity	Carbon dioxide	Nitrogen dioxide
1 a.m.	27.7°	82%	13%	12%
4 a.m.	27.2°	81%	11%	9%
7 a.m.	25.5°	90%	9%	6%
10 a.m.	30.5°	65%	9%	2%
1 p.m.	32.2°	61%	8%	2%
4 p.m.	31.6°	65%	8%	4%
7 p.m.	30°	70%	9%	6%
10 p.m.	28.8°	79%	10%	9%

VI. Conclusion and Future scope

Air pollution has affected environment and also our health on a large scale. This has led to the death of many innocent lives. This project provides information to the public about levels of air pollution, concentrating on reduction of air pollution. Even though the product developed has many features such as light weight and compact size, low battery power consumption, wireless communication over a wide distance and user friendly display of the data, but still many of the features can be added to make it more advantageous for different applications. An Oxygen sensor could be added to simultaneously monitor the complete contents of air and also use it for improving uncertainties. A high frequency transmitter and receiver pair over the frequency range of GHz can be used to avoid the mismatching problem faced during the designing of the prototype. So far the present system is designed mainly for the monitoring and observation applications. In the current version of the Air Pollution Monitoring System (APMS), the current data is displayed on the LCD. However, improved with an LCD display unit and memories, it can be used as a standalone portable instrument and a data logger. This APMS can also be connected to a PC via serial port. T1out of MAX232 transmits the final data to DB9 connector which passes the data to serial input of PC. The PC then displays the measured value of sensors by means of PC HyperTerminal. ZIGBEE module is used for safe and less expensive wireless communication which requires low power.

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