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Industrial Pollution Monitoring System

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Abstract:-- *As the countries become industrialized, the pollution level to our environments increases and hence is a major problem for the health of the population and also affects the ecosystem. The paper aims to devise a system to monitor pollution caused by the industries in a state by using the technology of wireless sensor networks (WSNs). The system is integrated with the global system for mobile communications (GSM) and the communication protocol used is zigbee. The system consists of sensor nodes, a control center and data base through which sensing data can be stored for history and future plans. The proposed system can be deployed to the industries for monitoring carbon monoxide (CO), sulfur dioxide (SO2) and noise concentration caused by industrial emissions due to process.*

Index Terms— *pollution, Arduino Uno, wireless sensor network, zigbee, GSM*

I. INTRODUCTION

With the increasing level of air pollution, there becomes a need of monitoring of the air pollution to save more human lives. Pollution is the presence of contaminants or pollutant substances in the air that interfere with human health or welfare, or produce other harmful environmental effects [1]. These pollutant substances usually result from vehicle emissions, Industrial emissions and volatile organic compounds. With the progression of advancements in technology, several innovations have been made in the field of communications that are transiting to Internet of Things. In this domain, Wireless Sensor Networks (WSN) are one of those independent sensing devices to monitor physical and environmental conditions along with thousands of applications in other fields. Wireless Sensor Networks is an excellent technology that can sense, measure, and gather information from the real world and based on some local decision process it transmits the sensed data to the user located in a distant area. These networks allow the physical environment to be measured at any point, and greatly increase the quality of the environment. WSN provides a bridge between the real physical and virtual worlds. It has the ability to observe the places where it is difficult to fix the wired system and at terrestrial environments at a fine resolution over large scales.

II. LITERATURE REVIEW

Henrik Madsen et al in 2004 introduces a computer aided modeling and pollution control tool (called PoLogCem – Pollution Logistic Cement)[2], with the following functionalities:

(i)The achievement for representatives' mathematical models for the environmental pollution process

(ii) The monitoring of the production process with pollution influence.

(iii)The searching for the optimal solutions for production planning, which minimize pollution effects

They integrated three principal modules (i.e. statistical modeling module, measurement management module and optimization module) in order to obtain a software architecture that is easy to manipulate and maintained. The module designed for modeling stage is able to assist the end user in experimentally determining the parameters of the environment pollution. Also a logistic module provides reports for monitoring the pollution level and the contribution of each specific item of equipment to the pollution level. The software system, called PoLogCem, is specially designed in order to scan the pollution activity specific for cement plants and to find logistical solutions with the purpose of pollution control in the cement industry. North, R., et al developed an integrated mobile environmental sensing system [3] to support the management of transport and urban air quality. Sensor nodes are deployed on vehicles and infrastructure to monitor traffic, weather and pollutant concentrations at far higher spatial and temporal resolutions and send data into a dynamically configurable 3 computing platform that supports both near real-time incident management and longer term strategic planning decisions. Völgyesi, P. et al introduced a Mobile Air Quality Monitoring Network (MAQUMON) that utilized moving vehicles equipped with sensor nodes to monitor air quality in a large area [4]. Each sensor node consisted of a microcontroller, an

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on-board Global Positioning System (GPS) unit, and a set of sensors to detect the concentrations of ozone (O3), Carbon Monoxide (CO), and nitrogen dioxide (NO2). The node was able to send the sensed data to the gateway in a car through the Bluetooth connection. When the car move, the sensor node detects the concentrations every minute and store the data tagged with location information into a memory. When the car moves to a Wi-Fi hotspot, the gateway in the car transmits the data to the server, and the data would be processed and published on the sensor Map portal. MAQUMON provides a record regarding air quality and pollutant dispersion within the area. But this monitoring system could not immediately send the monitoring data back. The work done by Liu et al. [5] proposes a Wireless Sensor Network (WSN)-based urban air quality monitoring system that is connected to a GSM system for centralized control by a LabVIEW program that stores sensed data in a database. They implemented the monitoring systems in the city road of Taipei to monitor the carbon monoxide (CO) concentration caused by vehicle emissions.

The work done by Jelicic et al. [6] introduces an Indoor Air Quality monitoring (IAQ) system using a sensor network that integrates a power management approach to reduce sensors energy consumption by using an adaptive duty cycling mechanism for metal oxide semiconductor (MOX) gas sensors.

III. HARDWARE ARCHITECTURE

It is divided into two sections: the transmitter and receiver section.

A. Transmitter section

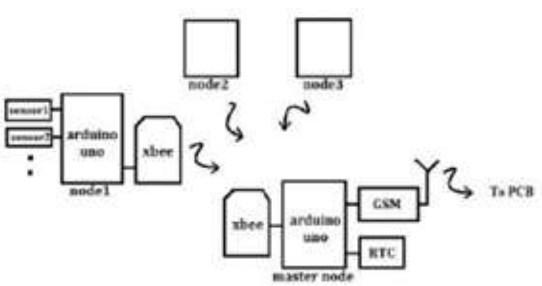

Fig. 1. Transmitter section

As shown in Fig.1, the transmitter section is comprised of all the industries in an area whose pollution levels are to be monitored by the PCB (Pollution Control Board). Each industry, referred to as a node, will have one GSM module which will be used to send a SMS containing data collected on pollution levels of various pollutants within the industry. Each node is made up of sensors, Arduino-Uno microcontroller board and an XBEE Series1 module (End Device).These nodes in an industry will be coordinated by one master node which comprises of XBEE Series1 module (Coordinator), RTC module (DS1307), Arduino-Uno and a GSM SIM900A module. The node along with the master node forms a network. The network protocol used for communication is 802.15.4. This master node will coordinate activities of all the nodes within the industry. At programmed intervals, master node will send signals to all the nodes in the industry to measure the pollutant levels and the nodes will respond to the master with data containing measured values of pollutants. Received data from all nodes will be processed and a final message along with the time of measurement (using RTC) will be framed and sent to the pollution control board using GSM module.

B. Receiver section

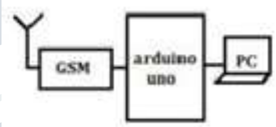

Fig. 2. Receiver section

As shown in Fig.2, at the receiver side, transmitted GSM message will be received by another GSM module which will be read by the controller and saved in the database.

IV. HARDWARE REQUIREMENTS

The proposed system is designed by integrating the following hardware modules as shown in Fig. 3:

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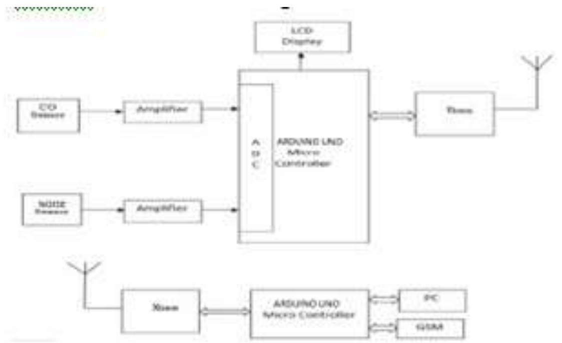

Fig. 3 System Hardware Architecture block diagram

(i) ARDUNIO UNO:

The ARDUINO UNO is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter

(ii) SENSORS USED:

The sensor array consists of two pollutant sensors which are Carbon monoxide (CO) and noise. Carbon monoxide detectors indicate the presence of CO in parts per million (ppm). The range of measurement of 10 to 1000 ppm is modest when compared to a gas analyzer; however they are more suitable for measuring ambient air quality. Interfacing with the sensor module is done through a 4-pin SIP header and requires two I/O pins from the host microcontroller. The sensor module is mainly intended to provide a means of comparing 8 carbon monoxide sources and being able to set an alarm limit when the source becomes excessive.

The sound sensor module provides an easy way to detect sound and is generally used for detecting sound intensity. It uses a microphone which supplies the input to an amplifier, peak detector and buffer. When the sensor detects a sound, it processes an output signal voltage which is sent to a microcontroller then performs necessary processing.

iii) XBEE:

XBEE is a particular brand of Zigbee compliant radios made by Digi International. XBEE is a wireless RF transmitting device which supports a self-checking 802.15.4 network protocol. The data out is transmitted serially from the UART using 8-N-1 formatting.(start bit, eight data bits(least significant first) and stop bit) The communication/terminal should be set with:

1. 9600 baud rate
2. No parity
3. 8 data bits
4. Stop bit

The XBEE modules can be configured in two ways: Transparent Mode (AT) and API Mode. The data packet transfer between XBEE always occurs in the same format no matter what command mode it is in. Each XBEE device can be either configured as coordinator or as an end device. The coordinator is responsible for coordinating and collecting data from end devices and maintaining the network, and end devices are responsible for sending data collected from sensors, directly to coordinator. The modules include a digital direct sequence spread spectrum base band modem and an effective data rate of 250 kbps.

(iv) RTC (Real Time Clock):

The DS1307 serial real-time clock (RTC) is a low-power, full binary-coded decimal (BCD) clock/calendar plus 56 bytes of NV SRAM. Address and data are transferred serially through an I2C, bidirectional bus. The clock/calendar provides seconds, minutes, hours, day, date, month, and year information. The end of the month date is automatically adjusted for months with fewer than 31 days, including corrections for leap year. The clock operates in either the 24-hour or 12-hour format with AM/PM indicator. The
DS1307 has a built-in power-sense circuit that detects power failures and automatically switches to the backup supply. Timekeeping operation continues while the part operates from the backup supply.

(v) CENTRAL MODULE:

The Central Server is a personal computer with accessibility to the Internet. The Pollution Server is connected to the Microcontroller with XBEE coordinator modem via RS-232 communication standard. The air pollution information sent from each end devices are collected to coordinator and then the data are saved to database of central server

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(vi) GSM

Global System for Mobile Communications (GSM) modems are specialized types of modems that operate oversubscription based wireless networks, similar to a mobile phone. A GSM modem accepts a Subscriber Identity Module (SIM) card, and basically acts like a mobile phone. This type of modem is an external device connected via a USB cable or a serial cable. In this project, the GSM modem is connected to the Microcontroller via Max 232(level converter). If the received data values exceed the limit values, the modem will send the alerting message with the current values to the responsible person and Authorities.

V. CALIBRATION

(i) MQ-7 (For Carbon dioxide):

- Connect the CO gas sensor module in the breadboard.
- Connect VCC pin of the sensor to 5 Volt and GND pin to ground of the power supply.
- Pre-heat the sensor for 48 hours to achieve more consistent sensor output. The burn-in eliminates any remaining moisture or contamination from the manufacturing process.
- The digital output pin of the sensor gives a logical ‘low’ when the CO concentration to which it is exposed crosses a particular threshold and is otherwise a logical ‘high’. This threshold is set by changing the resistance of the potentiometer present on the module.
- Sensor output voltage corresponding to a ‘high’ is around 5volts and that for a ‘low’ when CO is detected is below 1volt. Hence this sensor will be connected to the digital input pin of the controller.

(ii) NOISE SENSOR

The noise sensor was calibrated in GSPCB by exposing the sensor to a constant sound level by playing audio file at a constant volume and noting the sensor’s dc output voltage and the noise-meter readings. The dc output voltage was noted using a digital MultiMate as shown in Fig. 4.

Sensor output voltage(v)	Noise meter readings(dB)
5.18	50.06
5.17	69.7
5.16	70.1
4.9	75.6
4.6	79.9
4.35	81.5
4.45	83.5
3.81	87.8
3.16	91.3
3.03	97.2
2.93	102.7
2.85	102.6

Fig.4 Sensor output voltage for various noise levels

Based on these observations, an approximate noise level range corresponding to approximate output voltage can be calculated.

VI. SOFTWARE USED

SQLite database engine is used to create and access the database. The front end application is developed using C language in Visual Studio software. The fed values in the database are seen using SQLite Database Browser Portable Software which allows to add new records if new industries are to be added.

VII. CONCLUSION

Thus the parameters like Carbon Monoxide and noise level are monitored continuously and the data is sent to the pollution control board via GSM. Thus the environment is saved from several hazards of pollution. Since the system makes use of wireless sensor networks, it provides low power consumption, low cost and a convenient way to control real-time monitoring of pollution in industries. In future the system could be updated by monitoring other emissions like sculpture dioxide, carbon dioxide and nitrogen oxides. A dedicated website can be created for real-time pollution monitoring of the industries for an industrial estate. This system can be used for monitoring the concentration of air pollutants both at the indoor as well as at the outdoor environment.

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