Weather, Air Pollution, Rainfall Monitoring with ZigBee System

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Abstract: based air and rainfall detection system. The design and development of a ZigBee-based monitoring system is a key component of this paper. The proposed monitoring system is in need of the hour in metro cities of dense population countries like India. The carbon emission from industries and a large number of vehicles in metro cities in India demand low-cost, low-power, real-time distributed monitoring systems. We have chosen Pune city in Maharashtra, India for the implementation of the monitoring system due to the frequent changes in weather and rainfall conditions observed in 2019. Our main objective is to provide real-time monitoring of air quality at distributed locations by using ZigBee-based distributed real-time air quality monitoring. The extra efforts that we have done here is to observe and monitor Pollution levels after and before rainfall in Pune City, India. The highlight of this paper is the establishment of the interrelation of air pollution and rainfall and the comparisons of environmental monitoring

Keywords: *- ZigBee,AQI, rainfall monitoring, , air quality, weather monitoring, Pune India weather, GSM, GPRS, environment monitoring, Wireless sensor networks, MQ135.*

I INTRODUCTION

All Human mood swings are affected by weather conditions. Blue sky and sunny days are making human enthusiastic. The weather variables are influencing day-to-day activities. Recently Fani storm in Odisha, and Gaza storm in TamilNadu, Heavy rainfall in Pune, Flood situation in Kolhapur and Sangli district are few examples of the nature affecting day-to-day life in India. But due to technological advancements efficient disaster management saved lives of affected people. This disaster management is possible due to continuous monitoring of weather da Human mood swings are affected by weather conditions. Blue sky and sunny days are making human enthusiastic. The weather variables are influencing day-to-day activities. Recently Fani storm in Odisha, and Gaza storm in TamilNadu, Heavy rainfall in Pune, Flood situation in Kolhapur and Sangli district are few examples of the nature affecting day-to-day life in India. But due to technological advancements efficient disaster management saved lives of affected people. This disaster management is possible due to continuous monitoring of weather data.

A. Need of Rainfall monitoring

Prediction of rain is need of the hour for economy of country. Recent Heavy rainfall in Pune and Mumbai are one of the severe situations faced by these modern metro cities. On the other hand, in some parts of this district there was no rainfall at all. The monitoring of data of rainfall is useful for future predictions of rain in different regions of the country.

B. Need of Air Quality monitoring

Clean air is one of the basic requirements for maintaining good health. In Indian metros high pollution level, dense population, a smaller number of trees, high industrialization and modern life full of gazettes are the prominent factors that increase carbon emission. As per the News published in Times of India, Indian cities like Kanpur, Delhi, Mumbai topped in Bad Air Quality Index survey. These facts underline the need of monitoring weather data.

II. Literature Survey

Wireless ZigBee agriculture monitoring related to environmental parameters is considered in paper [3]. This paper is related to minimising human efforts, power and cost and to maximise accurate results with an control capacity of 254 devices applied related to various domains. [6] This paper introduces ZigBee-based weather monitoring for industrial requirements with connection to local network (LAN) via Ethernet port of the receiver system The system is used for monitoring the weather parameters and broadcasting.[6]

[4] ZigBee/IEEE 802.15.4 standard (Xbee Wireless module) is used. The paper's key point is showing alerts and display the weather/disaster warnings management. This system is built with, AVR for alerting weather and Plots are available with weather statistics in this paper. [4]

[5] The temperature and soil are the parameters considered by this paper. For wireless sensor network how the networking works and how the data is acquired, transmitted and displayed in real time is discussed in this paper [5].

[2] This paper describes the role of technology for weather monitoring. Satellite is useful for atmospheric studies and

radar is useful for scientists for prediction of natural calamities like formations of hurricanes, lightning, storms etc.

[9] In this paper, the author of the current paper Ms. Patil has experimented Implementation of web server using Beagle bone black for low cost intelligent monitoring and controlling of industrial parameters via internet. Sensed information was directly transmitted in the form of WebPages without need of PC. This paper is the source of motivation for ZigBee based experimentation.

[10] In this paper, the author of the current paper Ms. Patil has experimented with Raspberry Pi board-based monitoring (air, water level, garbage) using various sensors, and has been successfully designed and implemented. This paper is also the source of motivation for further experimentation.

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III . Motivation for work

The first motivation for this work is an article [7] published in the form of news in the daily Pioneer The article has the title "Rain pushes Air Quality Index (AQI) to good category." This article describes How Air Quality Index (AQI) increased after rainfall in the Delhi NCR region. The second motivation factor for this work is from the website "www .aqicn.org" [8]. On this website, Area real-time AQI is available [8]. The site provides rainfall for selected major Indian cities. The third motivation for this work is Awareness of factual data listed in Table I. Pure air contains very less Pollution like gases in Air namely CO2, NO2, and SO2.

Table I: Constituents of pure air mole content

Constituents of pure air (mole content)			
I.	**Pollution causing gases in Air**		
1.	Carbon monoxide	CO	0.000025
2.	Sulfur dioxide	SO_2	0.00001
3.	Nitrogen dioxide	NO2	0.000002
II.	**Significant Contents of Air**		
1	Nitrogen	N_2	78.084
2	Oxygen	O_2	20.947
III.	**Noble gases**		
1.	Argon	Ar	0.934
2.	Carbon dioxide	CO_2	0.035
3.	Neon	Ne	0.001818
4.	Helium	He	0.000524
5.	Methane	CH_4	0.00017
6.	Krypton	Kr	0.000114
7.	Hydrogen	H_2	0.000053
8.	Nitrous oxide	N_2O	0.000031
9.	Xenon	Xe	0.0000087
10.	Ozone	O_3	0.0008

But polluted air contains dangerous levels of Pollution like gases in Air namely CO2, NO2, and SO2. Due to pollution the physical systems or living organisms get adversely effected with disorders, discomfort which sometimes turn out to be very harmful. These effects may be long lasting and health damaging like coughing and heart disease. In high concentrations, NO2 may lead to respiratory problems also increased levels of SO2 contributes to acid rains.

IV. Problem statement

The primary objective of the system is to monitor real-time values of the rainfall and air pollution and establish their interrelation.

The secondary objective is to gather weather data from all the data servers, analyse and examine it to form graphs, pie charts and other various display graphs. And with the help of the gathered data from the servers create a graphical representation showing the relation between air pollution and rainfall.

Methodology for hardware

Hardware required for implementation is of following types:

A) Air Quality monitoring Hardware part

B) Rainfall monitoring Hardware part

A) Air Quality monitoring Hardware part

The proposed system is designed by integrating the following hardware modules is shown in Fig. 1. The system consists of an AVR (AT mega 16) microcontroller integrated with a sensor array. The hardware unit is also connected to a ZigBee module using the RS-232 interface. AT mega 16 microcontroller has RS232 serial communication done via ZigBee modem and a parallel connection is provided to the gas sensors. The connection between the gas sensors and the microcontroller is done by using auxiliary electronic circuits for signal conversion like OA (Operational Amplifiers) and transistors. Use of the signal conditioning is because of the very small output voltages provided by the sensors (mA range). The sensors and Zigbee are arranged as below.

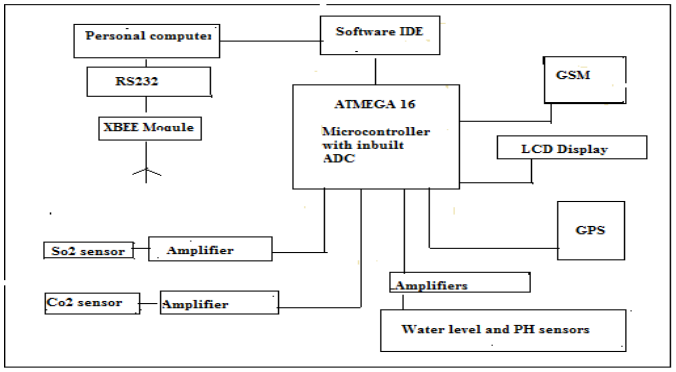

Figure 1: Basic block diagram for Air Quality measurement

a) The sensor array

The sensor array consists of 2 air pollution sensors:

- MG811 measures Carbon Dioxide (CO2),

• MQ135 measures air quality index including Nitrogen Dioxide (NO2), and Sulphur Dioxide (SO2)

The resolution of these sensors is enough for pollution monitoring. Each of the above sensors has a linear current output in the range of 4 mA–20 mA. The 4mA output corresponds to zero-level gas and the 20 mA corresponds to the maximum gas level. A simple signal conditioning circuit is designed to convert the 4mA–20mA range into 0–5 V to be compatible with the voltage range of the built-in analog to digital-converter in the AVR microcontroller. MG811 sensor is used to measure the CO2 level in the atmosphere. It is composed of a solid electrolyte layer, Gold electrodes, Platinum Lead, a Heater, a Porcelain Tube, 100m double-layer stainless net, Nickel and copper plated ring, Bakelite, and Nickel and copper plated pin. When the internal heating element is activated, this gas sensor responds to CO2 gas by generating a small voltage in proportion to the amount of CO2 gas present in the air. The sensor is a high impedance device and requires a buffer/amplifier to measure the output. It features good sensitivity and selectivity to CO2, low humidity and temperature dependency and long stability and reproducibility. It is used in air quality control, ferment process control, room temperature CO2 concentration detection and other applications.

b) Zigbee Module

While selecting wireless module as Zigbee, the main characteristic taken into consideration is low power consumption. ZigBee is the new short range, low power, and low data rate wireless networking technology for many applications. We have used two types ZigBee modules 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 collecting data and maintaining the other devices on the network. All other devices are known as Zigbee end devices (ZED) which directly communicate with the ZCM.

c) Central Server

The Central-Server is an off-the-shelf standard personal computer with accessibility to the Internet. The Pollution-Server is connected to the Zigbee-Modem via RS-232 communication standard. The air pollution information sent from each ZED is collected to ZCM. And then the data is saved to database of central server.

This database further generates graphs for ease of use and understanding of the behaviour of the gases and the amount of rainfall.

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B) Rainfall monitoring Hardware part

Existing measurement methods, protocols and standards are of the following types:

i. Non-recording gauges
ii. Recording gauges
iii. Satellite measurement
iv. Proposed digital water level indicator method

v. Non-recording gauges: Several types of non-recording gauges for the measuring stage are used in. The common types of gauges are:

(a) Graduated vertical staff gauge
(b) Ramp or inclined gauge
(c) Wire-weight gauge installed on a structure above the stream
(d) Graduated rod, tape, wire or point gauge for measuring the distance to the water surface.

ii. Recording gauges: Many different types of continuously recording stage gauges are in use. They may be classified according to both mode of actuation and mode of recording. A commonly used installation consists of a stilling well connected to the stream by pipes and a float in the stilling well connected to a wheel on a recorder by a beaded wire or perforated tape.

iii. Satellite measurement:

Remote sensing has the potential to provide several lakes and reservoir attributes. For example, surface area, elevation, location and identification calculated through operational navigational Chart maps. All these methods are expensive and difficult to maintain. In this case we have chosen an easy yet effective method to measure the level of water due to rainfall.

iv. Proposed Digital water level indicator method:

Proposed method is known as the digital water level indicator. This method is also used in petrol tanks of vehicles to indicate the level of petrol. The block diagram thus shows us how the level of water is sensed first and then it is amplified by operational amplifiers.

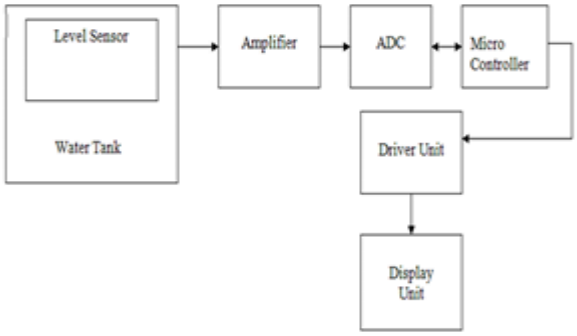

Figure 2: Basic block diagram for rainfall measurement

Further, the amplified output is given to the ADC to convert the signal to an electrical signal using signal conditioning circuits. This output is thus fed to the Atmega microcontroller which indicates us the actual level of the water collected due to rainfall. The value is thus finally displayed on the LCD.

v. **General working of proposed Wireless ZigBee based weather monitoring system**

The system contains two parts. One is the transmitter node and the other is the receiver. The transmitter part consists of

weather sensors, a microcontroller, and Zigbee and the receiver part consists of a PC interfaced with Zigbee through PC serial port. The system monitors data with the help of the respective sensors. The data from the sensors are collected by the microcontroller and transmitted to the receiver section through a wireless medium. All the parameters are viewed on the PC using a program on the receiver side. The air quality index is measured from the reading of the sensor array. For rainfall measurement, the water level indicator gives a measurement of Rainfall. Furthermore, temperature, humidity, and other environmental factors can be monitored using additional interfacing sensors which we have interfaced in this paper. Also, the system can be updated by interfacing wind speed sensors for future scope.

After taking the readings of air quality, the following classification is done. These levels are decided after Tests and calibration of system.

Index	Air Quality Description	Band
0-100	Clean Air	
101-125	Light Pollution	
126-150	Significant Pollution	
150 above	Heavy Pollution	

Figure 3: Basic block diagram for rainfall measurement

Figure 3 shows categorization of the air quality into 4 parts:

1. Clean Air 2. Light Pollution
3. Significant Pollution 4. Heavy pollution

IV. Software platforms

The AVR microcontroller is programmed using AVR Studio v.4. Programming is done with Embedded-C programming. Once the coding is done, the code is burnt onto the IC using a USB programmer and BAFO (USB to Serial) cable. The code is burnt using Flash Magic software and tested on HyperTerminal or on Docklight v1.9. The front end of the system is programmed on Java and the database is built using MySQL server. Future scope of this work is the development of an Android/IOS application which can be released in the app store for free.

V. Test Results

The system shows the following results.

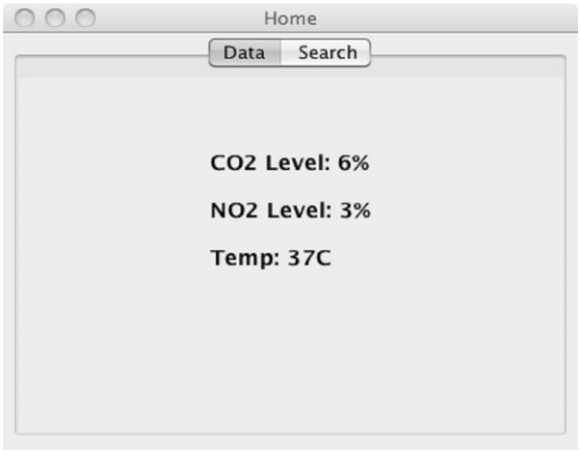

Figure 4: Actual screenshot of frontend-Sample data

Fig.4 shows actual screenshot of frontend- sample data taken at Location of University circle.

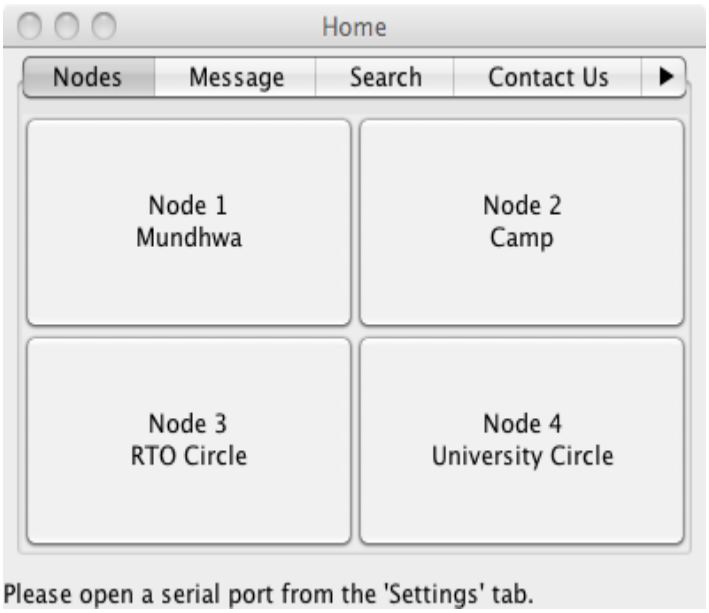

Figure 5: Actual screenshot of frontend-Home screen

We have placed our system assembly at the following locations in pune,to get diversified results.

Node1: Mundhwa Region Pune
Node2: Camp Region Pune
Node3: RTO circle Region Pune
Node4: University circle Region Pune

From Fig.6 we can see the interrelation between CO2 and rainfall. With the increase in rainfall, the ppm of CO2 decreases. Hence the pollution decreases showing inverse proportionality.

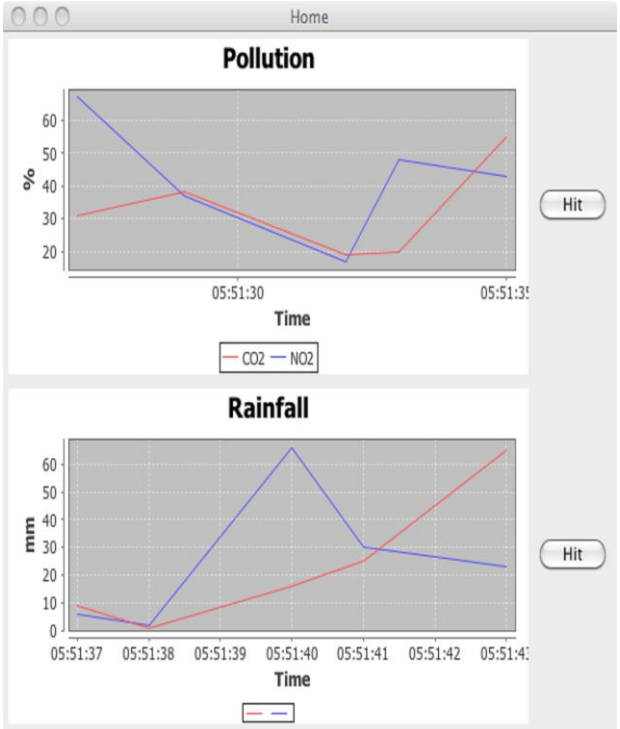

Figure 6: Frontend-Graphs showing inverse relationship of Pollution after rainfall

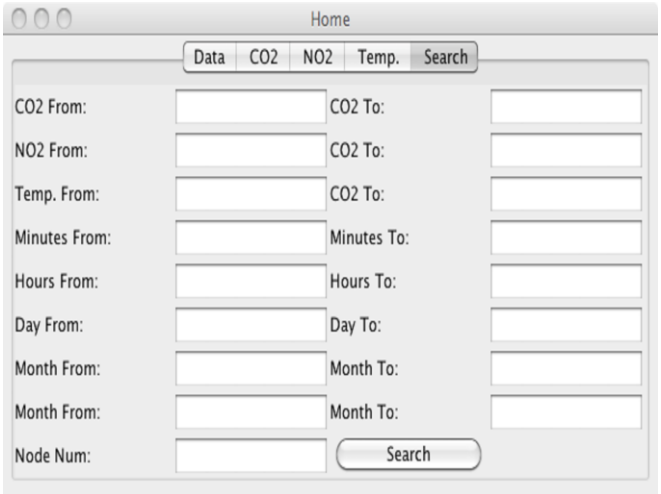

Figure 7: Front end display for Air Quality for MQ135 SENSOR

The most important part of establishing the relationship between rain and Air quality is the selection and calibration of the sensors in the sensor array. While selecting the sensor, the main criteria is selecting a sensor that should be small, light-weight and low on power consumption, low temperature and humidity dependency. Another expectation for selection is it. should be easily available in the market so that just in case of damage, it can be easily replaced. We have selected MQ135 sensor based on the above expectations. For getting readings from sensors we are using following front-end display design as shown in figure 7.

VI. Conclusion

Primary objective of this work is to provide real time weather monitoring system using Zigbee technology as wireless sensor network. The secondary objective is to establish the interrelation between CO2 and rainfall. With increase in rainfall the ppm of CO2 decreases. Hence the pollution decreases showing inverse proportionality.

This paper describes implementation of the weather monitoring system using ZigBee technologies and embedded system. The pollution data from various mobile sensor arrays can be transmitted to a central server that makes this data available on the Internet.

This server also displays data regarding the amount of rainfall in a region and the quality of rain water. The server then creates a database which can be accessed anytime locally (on the PC it is stored) or even globally (over the World Wide Web). The main server gathers all the data, analyses and examines it to form graphs, pie charts and other various display graphs. With the help of the gathered data the server creates a graphical representation showing us the relation between air pollution and rainfall.

VII. Refernces

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