Air Pollution Monitoring using GIS and Wireless Networking for Air Quality Management

Arun Kumar Yadav
M.Tech (Robotics engineering)
H.No. 612,2nd Floor,sector-2,
Panchkula,Haryana,india.

Pooja Prathihar
M.Tech (Robotics engineering)
Sector –1,h.no.366,vasundhara
Ghaziabad,uttar Pradesh,india

A.V.N.R.Sai Shiva
M.Tech (Robotics engineering)
h.no:s2c148,sachivalayanagar,
vanasthalipuram,Hyderabad

ABSTRACT
Air pollution is a serious problem in thickly populated and industrialized areas in India especially in Delhi. The air pollution in India is abundant especially in areas where pollution Sources and human population are concentrated .Economic growth in industrialization are proceeding at a rapid rate accompanied by increasing emissions of air polluting sources .Environmental impacts of air pollutants have impact on public health ,vegetation , etc. To prevent or minimize the damage caused by atmospheric pollution suitable monitoring systems are urgently needed which can rapidly detect polluting sources for monitoring. It is important that the current real time air quality monitoring system controlled by GIS (Geographic information system) should be adapted to alleviating this problem. Some of the existing instruments for air pollution monitoring are Fourier transform infrared (FTIR) instruments, gas chromatographs and mass spectrometers. These instruments provide fairly accurate and selective gas reading .but high cost and large size and maintenance cost made them unfavorable for monitoring application on large scale .some of low cost ,small size gas monitoring techniques are electromechanical, infrared, catalytic bead ,photo ionization .The main objective of this work is come up with cost effective, reliable , scalable and accurate real time air pollution monitoring system with wireless sensor network .commercially available electrochemical and resistive heating type sensor is used to sense like gas CO ,NO ,Co2,.So as to carry out air pollution monitoring over an extensive area a combination of ground measure through inexpensive sensors and wireless GIS will be used for monitoring purpose

KEYWORDS
ZigBee, Xbee, WSN pollution node, Environment, GIS, Air pollution

1. INTRODUCTION
Industrialization increases the degree of Automation and at the same time it increases air pollution by releasing unwanted gases in the industrial area Delhi [1].To detect the percentage of pollution we use array of sensor to measure gas quantity in physical environment the sensor convert them into electrical signal for further processing. These sensor node networks are connected through wireless network and gives wireless sensor network.

Main functioning unit Composed of: A sensing unit is designed and programmed to sense gas pollution in air in busy area Delhi that can sense humidity, light, pressure etc. A converter that transforms the sensed from an analog to a digital signal a processing unit in the microcontroller process the signals sensed from sensor with the help of embedded memory operating system, associated circuitry.

A Radio component that can communicate with the ZigBee node or ZigBee router which collect the sensed pollution gas level from sensor node and forward to pollution server .Powering to these component is typically is one or two small batteries .there are also some wireless sensor utilized in application that uses a fixed value, wired power source and do not use batteries as a power source.

In an external environment where the power source is batteries wireless sensors are placed in the area of interest that is monitored in a known or random fashion .the sensor self – organize themselves in a radio network using a routing algorithm, monitor the area for measure the gas level in air and transmit the data to the central node or called sink node

2. ZIGBEE STANDARD (2.4GHZ RF Module)

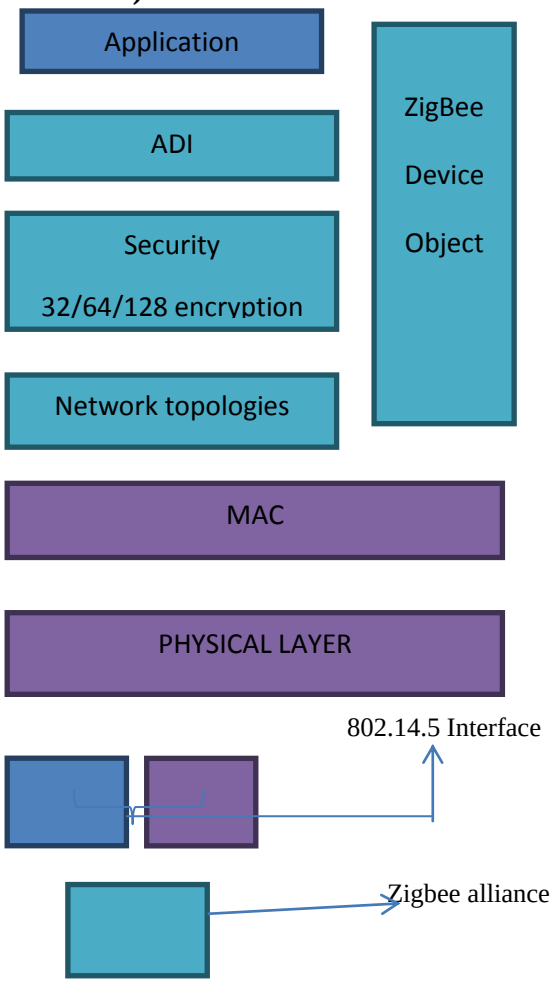

Fig 1 .Architecture of ZigBee standard

The Zigbee module supports star , tree and mesh topology .Zigbee coordinator (ZC) is responsible for imitating and maintaining the device on the network and all other device known as end devices (ZE) including routers (ZR) directly communication with Zigbee coordinator .In mash and tree topologies the coordinator (ZC) is responsible for initiating the network with default values and choosing certain key network parameters but the network may be extended by the use of router .

In addition this band provides highest achievable data rate of 250Kbps and 16 communication channel between 2.GHZ to 2.4835GHZ at the physical layer .Typical communication distances are within 30 meter in an indoor non line of sight environment depending on specification of module. But the problem related to range can be solved by applying Routing algorithm at the network layer.

2.4GHZ bands are commonly accepted wireless communication products throughout the world because of ISM (Industrial, scientific, medical) Band .Calibration of CO2 Gas using Gas sensor: Figaro's TGS4161 is a solid electrolyte (a type of solid state sensor) CO2 sensor with detection range of 350 ppm to 5000ppm . the sensitive element of the sensor consist of a solid electrolyte formed between two electrode, together with a printed heater substrate .CO2 concentration is measured by monitoring the change in electromotive force (EMF) generated between the two electrode .this type of solid electrolyte sensor features selectivity towards target gas, small in size, low cost and has long life expectancy (>10) years.

3. SENSOR NODE FUNCTIONALITY

The proposed pollute on node is designed by integrating the sensor associate circuitry Atmega 328 low power microcontroller and Xbee communication module.

Design and sensor node consist of 4 basic functionalities

(a) Signal Conditioning
(b) Sense the changes in Air: these sensor are used to sense the change in the gas concentration of various pollutions such as carbon monoxide , carbon dioxide, and sulphur concentration in air .As the output of the sensor are analog signals , strength and correctness of signals need to assured .
(c) Signal Amplification: As the signal detected by the sensor are need to be amplified and regenerated to increase the accuracy of the system.
(d) Signal Calibration: DC in Atmega 328 microcontroller provides the 10 bit resolution provides mapping between analog input signal digital signals for processing.

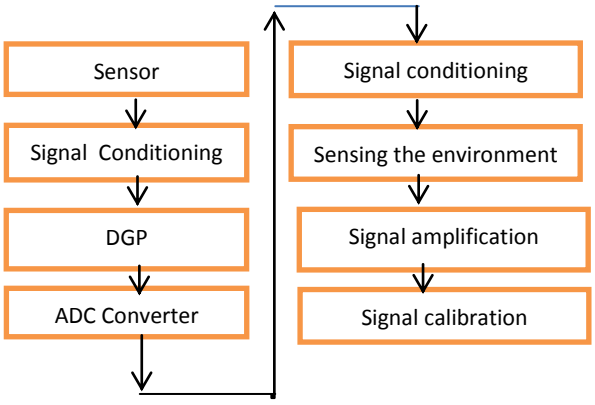

Fig 2: Design of sensor node network

3.1 Signal conditioning

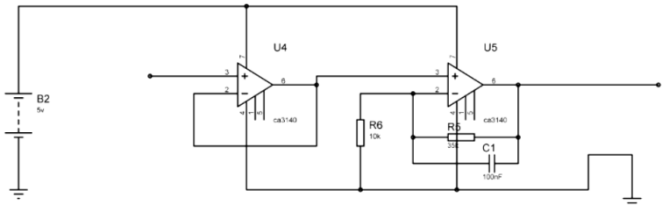

Fig 3: Signal conditioning circuit for CO2 sensor – TGS 4161

CO2 sensor with detection range of 350 ppm to 5000ppm and the sensitive element of the sensor consist of a solid electrolyte formed between two electrode, together with a printed heater substrate.CO_2 concentration is measured by monitoring the change in electromotive force (EMF) generated between the two electrode .this type of solid electrolyte sensor features selectivity towards target gas ,small in size ,low cost and has long life expectancy (>10) years .

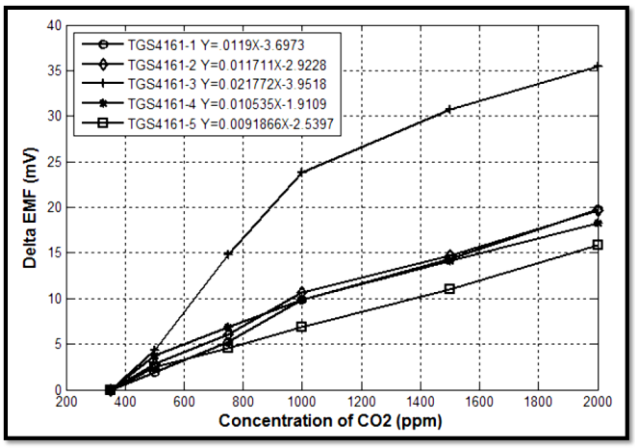

Fig 4: concentration of co_2

The group of various sensors are connected to analog ports of the microcontroller. The build in analog to digital converter (ADC) in microcontroller unit is used to convert the analog signal to digital values. IDE of arduino board is used for writing the coding in microcontroller.

3.2 Processing Unit

Atmega 328p microcontroller :The Atmega 328p is main unit for pollution Detection system [7].the operating system that is run in microcontroller ,coordinates factor measurement process and makes link with Xbee module for the sending the data to the Zigbee router [8]. Microcontroller is designed on a development board that provides RSS232 serial communication to the Xbee modem and GPS receiver and a parallel connection to the pollution sensor and main flow is shown in fig 5.

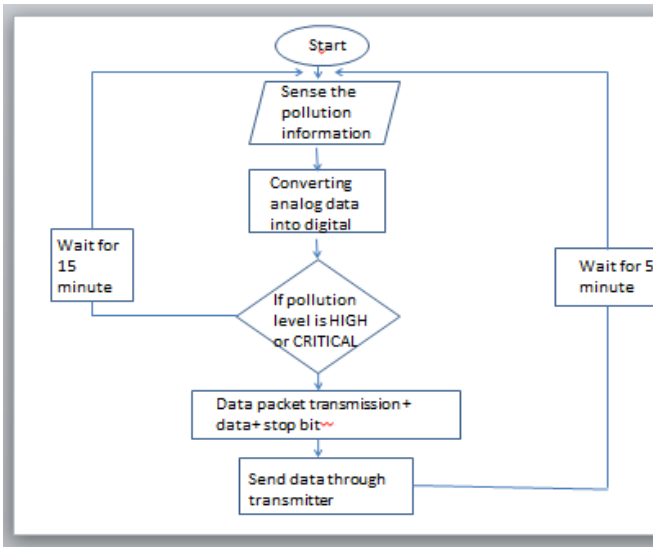

Fig 5: Process chart of data transmission of pollution information

3.3 Pollution detection unit

The array of sensor consist of three sensors used to detect carbon monoxide ,carbon dioxide and sulphur dioxide in air .for example MQ- 7 Sensor measure the CO percentage from 20ppm to 2000ppm in air .Each of above sensor has a linear current output in the range of 4ma-20ma .the value 4mA Corresponds Zero level gas and 20mA corresponds high level gas at (+5v).A simple Signal Conditioning circuit is designed to convert 4mA-20mA ranges into 0-5V to be compatible with voltage range of the built in analog to digital converter in the microcontroller .

3.3.1 Xbee Transceiver module

Two type of Xbee module are used in simulation to establish the small wireless sensor network for pollution monitoring system .one module is to use to transmitter and second as receiver .the network is controlled by devices called the ZigBee [3] coordinator modem (ZCM).ZCM is responsible for collecting data and maintaining the other devices on the network and all the other devices known as Zigbee end devices (ZED) can directly transfer the data to the ZCM.

The gas detection system is an off-the -shelf standard personal computer with accessibility by user interface .Ardiuno board is used in our simulation. The output of Atmega 328 microcontroller is connected to Xbee module to store the results in internet .Data collected in internet can be used by various client.

3.4 Hardware unit

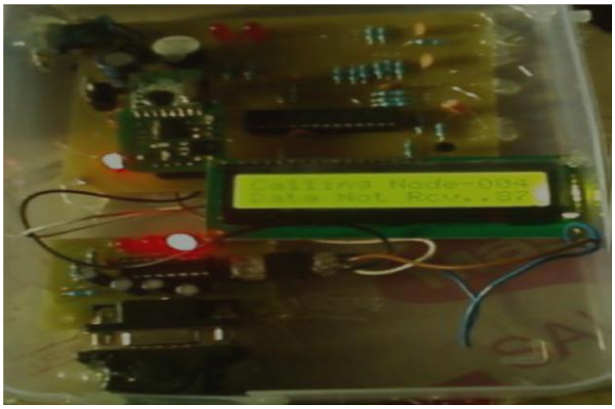

Fig 6: Data Receiver module

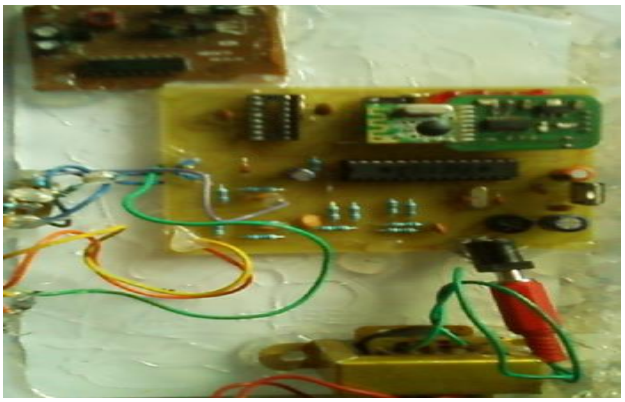

Fig 7: Data transmitter module

4. RESULTS:

:

Fig 8: Data Monitoring Graph showing levels of CO2 for Node

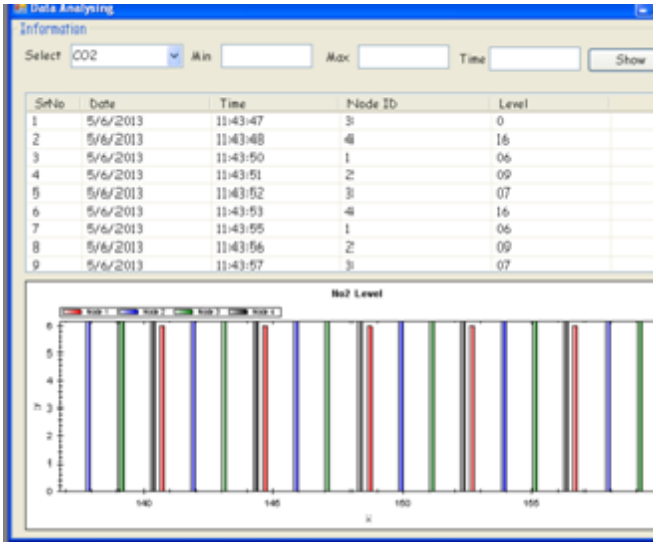

Fig 9: Data Analyzing Graph showing pollution levels with Date and Time

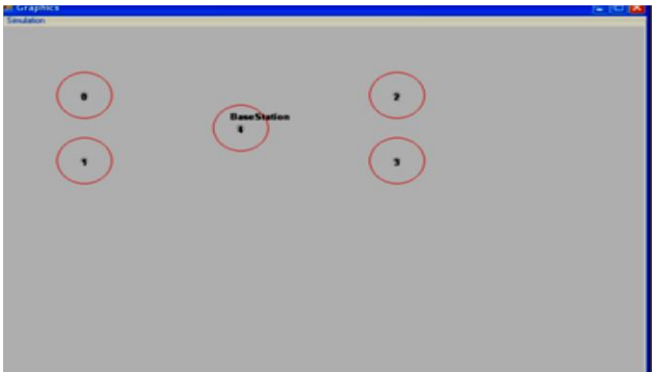

Fig10: Simulation of Nodes: Four nodes sending data to single receiver

5. COMPARITIVE STUDY OF AIR POLLUTION MONITORING SYSTEMS

The techniques implemented by us in transmitter and data received have been implemented in various countries .the process mentioned below is a methodology which is done in Politehnica" University of Timisoara in Romania which gives a comparative study between two methods:

5.1 Method for CO measurement and monitoring

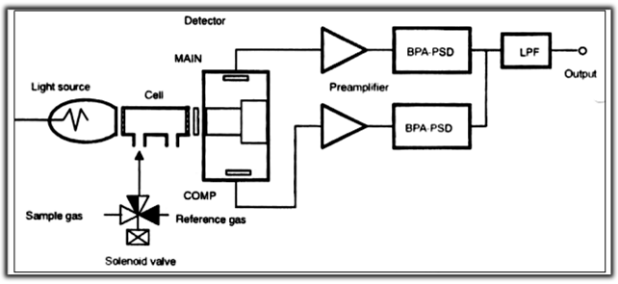

Fig 11: co measurement and monitoring

CO measurements uses the modulation that occurs with infrared absorption of gas taken in samples itself when sample gas are alternately sent to its cell at a certain flow rate using a valve which is actuated at a very low frequency . Until the gas concentration of the measured component is changed, the output directly comes to zero, therefore, the zero drift does not occur. Since the instrument also uses the same type detector.

5.2 Methodology implemented in Chennai:

In this study, three solid state gas sensors were used to measure three gases are linked with GPS through ARM processor board. The chennai city map was digitalized with GIS and GPS by moving around the city then the digitized map was fed into the internet. ARM Processor is a type of processor which is used tolink different outputs. It also helps to upload the linked data to the internet..ARM processor and different modules combinedly called as ARM module. The above said three sensors and GPS are linked through ARM module, then it is fed into the server through laptop and then it is uploaded to the internet.

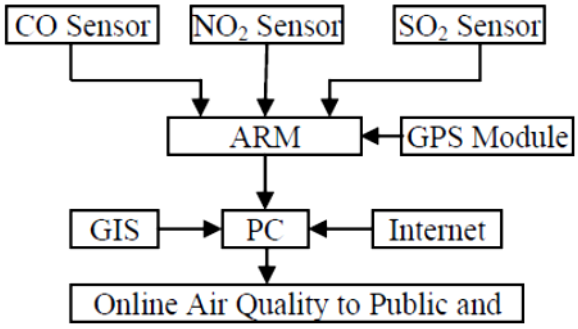

Fig12: flow chart of process of Arm module for online air quality

6. CONCLUSION

The purposed system is implemented with four transmitter module (node1 ,node 2 ,node3 ,node 4) and one receiver module .after successful implementation of proposed system the following fig 1shows the hardware device snapshot and the different results taken when the system is tested successfully. So, the air quality system should not be only monitoring through LCD it also should have the capability of locating a place where air quality is low using GPS and GIS .For this wireless internet GIS has to be used to have continuous monitoring of all the places as shown above through 4 nodes and a single master device which communicates with the slave and more ad-hoc networks mechanisms can be used to serve this purpose .Rather than showing the status of the monitoring the air quality such as good, poor, hazardous etc. it should be more in detail specifying more details about the content of the hazardous gases composition etc.

7. REFERENCES

[1] M.de Boer, 'Facing the Air Pollution Agenda for the 21stCentury,T.Schneider,ElsevierScienceB.V.:Netherland,1998,pp.3-8.

[2] N.D. van Egmond, 'Historical Perspective and FutureOutlook,in Air Pollution in the 21st

Century',Priority Issuesand Policy, T. Schneider, Elsevier ScienceB.V.:Netherland,1998,pp.35-46.

[3] JosC A. Gutierrez "ON THE USE OF IEEE 802.15.4 TOENABLE WIRELESS SENSOR NETWORKS IN BUILDING AUTOMATION " IEEE 2004

[4] L. Zucatto, A. Biscassi ," ZigBee for Building Control Wireless Sensor Networks" in conference IEEE- 2007

[5] O. PUMMAKARNCHANA and N. K. TRIPATHI, "Air pollution monitoring using semiconducting gas sensors and Internet GIS" , 5th WSEAS International Conference on Instrumentation, Measurement and Systems.

[6] http://en.wikipedia.org/wiki/Air_pollution,Wikipedia

[7] Jong-Won Kwon,Yong-Man Park, Sang-Jun Koo, HiesikKim, Design of Air Pollution Monitoring System Using ZigBee Networks for Ubiquitous-City,in Proceedings of the2007 International Conference on Convergence InformationTechnology, Vol. 00,2007,pp. 1024-1031.

[8]]GENG Jun-tao, "An Atmosphere Environment MonitorSystem Based on WSN ", International Journal, XIHUA university, vol. 26,2007, pp.47-51.

[9] Nihal Kularatna ; Univ. of Waikato, Hamilton ; Sudantha 'An Environmental Air Pollution Monitoring System Based on the IEEE 1451 Standard for Low Cost Requirements' Sensors Journal, IEEE (Volume:8 , Issue: 4)

[10] Davila, S, Beslic, I., Pecar-Ilic, J,Sega. K ' An automated web-based system for air quality monitoring' , MIPRO, 2011 Proceedings of the 34th International Convention,pages 819-819

[11] Marshall, J " Developing Internet-Based GIS Applications", Vol.11, 2002, pages:16-19.

[12] Galadari , "Mapping Urban Air Quality Analysis in GIS to Identify Sources of Ambient Pollution in Real-Time," Map Middle East Conference, 23 – 25 April 2005.

[13] David Hasenfratz, Olga Saukh, Silvan Sturzenegger, and Lothar Thiele 'Participatory Air Pollution Monitoring Using Smartphones',Switzerland.