

Pollution Monitoring System using Wireless Sensor Network in Visakhapatnam

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Abstract— As the technology increase, the degree of automation (minimizing the man power) in the almost all sectors are also increases. Wireless Sensor Networks (WSN) are gaining the ground in all sectors of life; from homes to factories, from traffic control to environmental monitoring. The air pollution monitoring system contains sensors to monitor the interested pollution parameter in environment. We simulated the three air pollutants gases including carbon monoxide, carbon dioxide & sulphur dioxide in air because these gases decides the degree of pollution level. We can also apply the approach in various applications like leaking cooking gas in our homes, to alert the workers in oil & gas industry to detect the leakage etc. This simulation creates the awareness in people in cities.

Keywords— Zigbee , Xbee ,WSN, Pollution Node ,ADC

I. LITERATURE SURVEY

Due to recent technological advances, the construction material for small and low cost sensors became technically and economically feasible. Even though, Industrialization increase the degree of automation and at the same time it increases the air pollution by releasing the unwanted gases in environment especially in industrial areas like visakhapatnam. Inorder to implement the project, we selected four areas to deploy the ppplication in visakhapatnam. To detect percentage of pollution ,we used the array of sensor to measure gas quantity in the physical environment in surrounding the sensor and convert them into an electrical signals for processing. Such a signal reveals some properties about interested gas molecule. A huge number of these sensors nodes can be networked in many applications that require unattended operations creates a wireless sensor network. Wireless sensors are devices that range in size from a piece of glitter to a deck of cards. Integration of various components create the air pollution monitoring system..

They are functionally composed of:

A Sensing unit that is designed and programmed to sense gas pollutants in air in four busy areas in visakhapatnam. Some

common examples of properties or parameters that are monitored are light, temperature, humidity, pressure, etc. a converter that transforms the sensed signal from an analog to a digital signal;

A Processing Unit in the Microcontroller, process the signals sensed form sensor with help of embedded memory , operating system and associated circuitary.

A Radio component that can communicate the sink node or zigbee router which collects the sensed pollution gas level from sensor node and forwards to pollution server which is in our campus.

Powering these components is typically one or two small batteries. There are also wireless sensors utilized in applications that use 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 an area of interest that is to be monitored, either in a random or known fashion. The sensors self-organize themselves in a radio network using a routing algorithm, monitor the area for measure the gas levels in air , and transmit the data to a central node, sometimes called a pollution server or base station (interfaced with coordinator), or sink node(interfaced with router), that collects the data from all of the sensors. This node may be the same as the other detection nodes, or because of its increased requirements, may be a more sophisticated sensor node with increased power. The most advantage of wireless sensors is that they may be implemented in an environment for extended over a time period, continuously detecting the environment, without the need for human interaction or operation.

II. ZIGBEE STANDARD

The ZigBee standard is the new short range, low power, low data rate wireless networking technology for many real time application. It is best specified the bottom three layers (Physical, Data Link, and Network), as well an Application

Programming Interface (API) based on the 7-layer OSI model for layered communication systems.

Figure-1 shows the layered architecture adopted by the alliance industries. It should be noted that the ZigBee Alliance chose to use an already existing data link and physical layer specifications. These specifications are the published IEEE 802.15.4 standards for low rate personal area networks(PAN) as shown in Figure 1.



Figure 1 Zigbee layered Architecture

Communication network is composed of many nodes, each of which can interact by transmit and receive data over communication channels. The ZigBee network model supports star, tree and mesh topologies as shown in Figure 2. The ZigBee coordinator(ZC) is responsible for initiating and maintaining the devices on the network, and all other devices, known as end devices(ZE) including routers (ZR), directly communicate with the ZigBee coordinator. In mesh and tree topologies, the coordinator(ZC) is responsible for initiating the network with default values and for choosing certain key network parameters but the network may be extended through the use of routers. The configurations of coordinator and router using X-CTU interface shown in Figure 6. In tree networks, routers move data and control messages through the network using a hierarchical routing strategy.

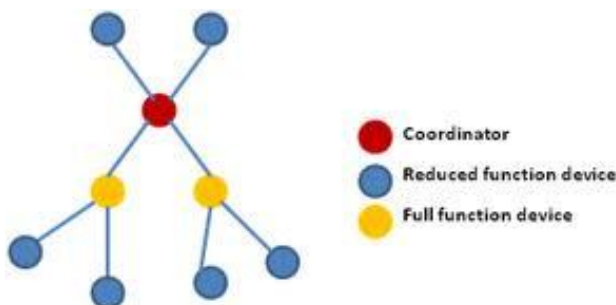


Figure 2: Pollution Network Topology

The IEEE 802.15.4 standard supports three frequency bands of operation: 868MHz, 916MHz and the 2.4GHZ bands for

ZigBee (license free bands). 2.4GHz bands are used the most commonly accepted wireless communication products throughout the world because of ISM (Industrial, Scientific, Medical) band. In addition this band facilitates the highest achievable data rate of 250Kbps and 16 communication channels between 2.4GHz and 2.4835GHz at the physical layer. Typical communication distances are within the range from 30 meters in an indoor non-line of sight environment to over 100 meters in a line of sight environment depending on specifications of module. But problems related a range can be solved through applying routing algorithm at the network layer. Although defined as 25mW in the world, transmit output power of ZigBee is limited within 10mW. Therefore ZigBee modules employ dipole type antenna to increase gain of antenna.

III PROBLEM ANALYSIS

Although the urbanization brings a higher economic development, the excessive population concentration will cause environmental damage and pollution like air pollution , noise pollution ,water pollution etc. Due to leakage of gas in the real time applications like cooking (LPG) gas in our homes, leakage in oil & gas industries, leakage in pipelines of transfer of LPG gas & exposures to pollutants etc need to be detected & may results in the harm to human systems like nervous, cardiovascular systems.

Thus in our research , a real time monitoring of three gases are simulated in real environment. Gases that are monitored in our implementation are Carbon monoxide ,carbon dioxide & sulphur dioxide. In our simulation these three gases are successfully tested in four areas. We extended our simulated results to update in web.

III. HARDWARE ARCHITECTURE

A.s Sensor Node functionality:

The proposed pollution node is designed by integrating the Sensor associate circuitry, Atmege 328p low power microcontroller and Xbee communication module. Design of Sensor node consist of 4 basic functionalities

a) Signal conditioning

the time gap between amount of gas concentration deposited on the sensing plates in heater and time requires to clear the gas concentration on the sensing plates..

b) Sense the changes in air

Three sensor are used to detect the changes in gas concentration of various pollutions such as Carbon monoxide , carbon dioxide & sulphur concentration in air. As the output of the sensors are analog signals, strength and correctness of signals need to assured.

c) Signal Amplification

As the signal detected by the sensors are need to be amplified and regenerated to increase the accuracy of the systems.

d) Signal calibration

ADC in Atmege 328p microcontroller provide the 10 bit resolution , provides the mapping between the analog input signal to digital signals for processing.

Sequence of steps in design of sensor node is shown in Fig. 3.

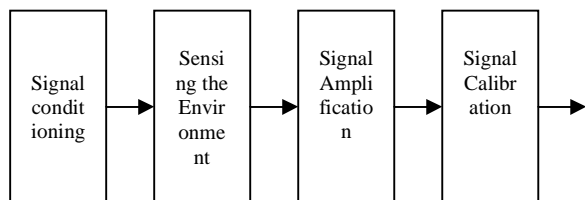


Figure 3: Design of pollution sensor node

The group of various sensor are connected to analog ports of the microcontroller. The build-in Analog to Digital Converter(ADC) in micro-controller unit is used to convert the analog signal to digital values. IDE of Ardiuno Uno board was used for writing coding in microcontroller.

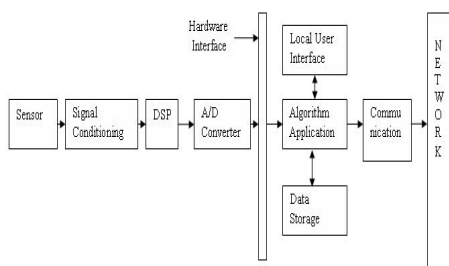


Figure 4. System Building Blocks.

B. Processing Unit : Atmega 328p microcontroller

The Atmega 328p microcontroller is the brain of Pollution Detection unit [10]. The operating system that runs in the micro controller, coordinates the substances measurement process & the acquisition of the change in gas percentages in air and coordinates with the Xbee module for data transmission to the zigbee router[11]. The microcontroller is fabricated on a development board that provides an RS232 serial communication to the Xbee modem and GPS receiver and a parallel connection to the pollution sensors and the main flow of control was shown in figure 5.

The connection between the pollution sensors and the Atmega 328p microcontroller can't be made directly because of the very small output voltages provided by the sensors (in mA). This problem is solved by using auxiliary electronic circuits

for signal conversion like OA (Operational Amplifiers) and transistors.

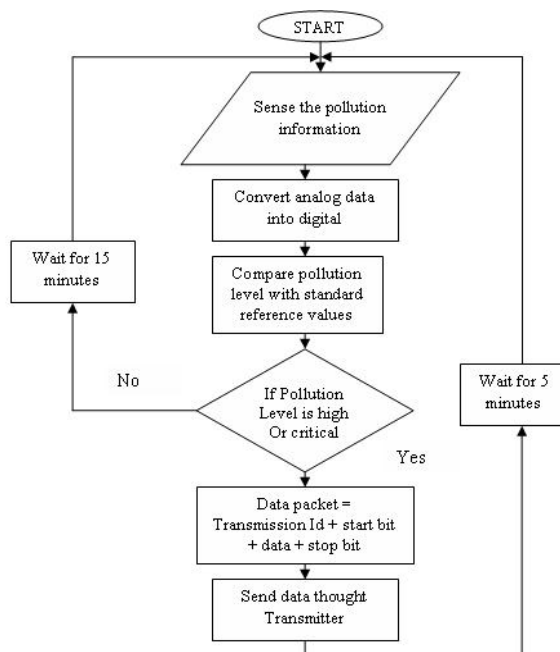


Figure 5 :Flow of control

C. Pollution detection unit

The array of sensors consists of three sensors, used to detect the Carbon monoxide , carbon dioxide & sulphur dioxide concentration in air for example MQ-7 sensor measure the CO percentage from 20 ppm to 2000 ppm in air. Each of the above sensors has a linear current output in the range of 4 mA–20 mA(minimum and maximum values). The 4 mA output corresponds to zero-level gas and the 20 mA corresponds to the maximum gas level (+ 5 V). A simple signal conditioning circuit is designed to convert the 4 mA–20 mA range into 0–5 V to be compatible with the voltage range of the built-in analog-to-digital converter in the microcontroller.

D. Xbee Transceiver module

Two types XBee modules are used in our simulation to establish the small wireless sensor network for pollution monitoring system. One module used as Transmitter and second as Receiver. X-CTU software was used to configure the Xbee modules as co-ordinator and router as shown in figure 6.

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, and all other devices, known as Zigbee end devices(ZED) can directly transfer the data to the ZCM.

The ZigBee module is hardware platform of wireless device. The modules realize the basic function of Z-MACI and Physical layer, such as transmit and receive, modulation and demodulation, channel and power control. They operate at 2.4GHz frequency ISM band wireless communication. The modules include a digital direct sequence spread spectrum base band modem and an effective data rate of 250 kbps.

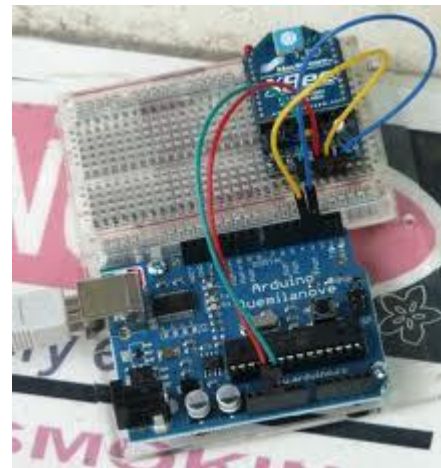


Figure 7: Setup of pollution sensor node

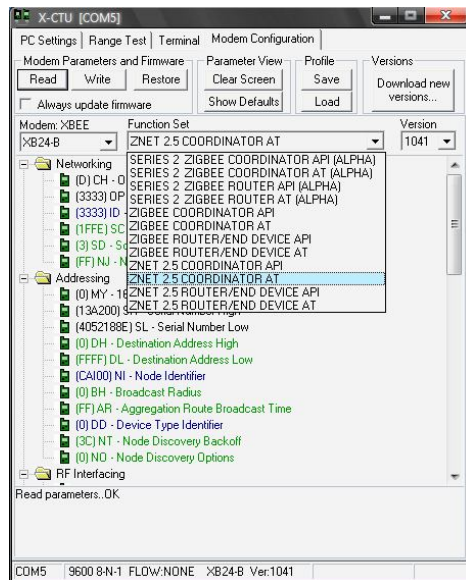


Figure 6: Configuration of X-CTU as coordinator & router

They employ the EM2420 2.4GHz radio frequency transceiver and the ATMEL 8-bit AVR microcontroller. They also exhibit a nominal transmit of -1.5dBm and a receive sensitivity of -92dBm. When powered at 3.0V, the modules draw 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.

E. Simulation of Pollution Detection Systems

The Gas Detection System is an off-the-shelf standard personal computer with accessibility by User Interface. Arduino board was used in our simulation. The output of the ATmega 328p microcontroller was connected to Xbee module to extend our project to store the results in internet. Data collected in internet can be used by various clients like state transport authorities, Insurance companies, tourists etc.

IV. SIMULATION RESULTS

The behavior of three sensors observed in various conditions and heating plates in MQ-7 sensor produces the more heat even for small change of the gas concentration and two sensor get effected during simulation. We also observed that material used in construction of sensor, place a vital role in accuracy and performance of the pollution system.

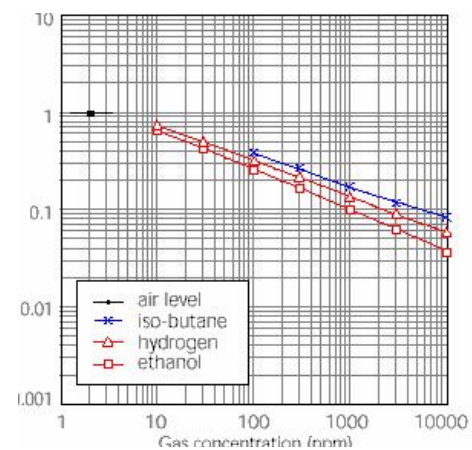


Figure 8: Pollution concentration in air

MQ-7 sensor composed by micro AL₂O₃ ceramic tube, Tin Dioxide (SnO₂) sensitive layer, measuring electrode and heater are fixed into a crust made by plastic and stainless steel net. The heater provides necessary work conditions for sensitive components. MQ-7 is able to detect from 20 ppm to 2000 ppm of concentration in environment. Figure 9 shows the deposit of amount of carbon monoxide concentration on heater.

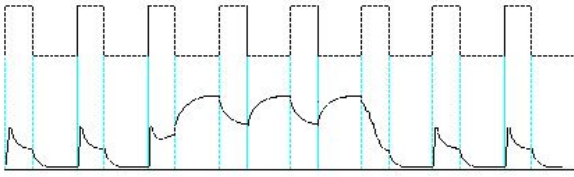


Figure 9: Sensitivity of Carbon monoxide sensor
V. CONCLUSION

Dependence & Power consumption of sensor nodes need to be minimized and functionality of the each step should be optimized (maximize the cohesion and minimize the coupling). The selection of sensor and material used in construction of the sensor should select such that the there should be minimum changes in the accuracy of the system. As the increase of Carbon dioxide concentration (especially in urban area) and deforestation is a major reason to cause a global warming in addition to other pollutants. This paper describes implementation constraints and attributes or measure of the various pollution monitoring system using ZigBee technologies and embedded system using efficient way.

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