Big Data and Computing Visions

www.bidacv.com

Big. Data. Comp. Vis. Vol. 3, No. 1 (2023) 1–7.

Paper Type: Original Article

Air Pollution Monitoring System based on Wireless Sensor Networks

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Citation:

Osintsev, N. (2023). Air pollution monitoring system based on wireless sensor networks. *Big data and computing visions, 3*(1), 1-7.

Received: 16/03/2022 Reviewed: 17/04/2022 Revised: 11/05/2022 Accept: 20/06/2022

Abstract

Air pollution is the biggest environmental hazard that cannot be ignored. Due to increase in number of industries and urbanization increases air pollutants concentrations in many areas because of this different changes are been happening in human life like health issues and as well as other living organisms. We have some pollutant emission monitoring systems, like Opsis, Codel, Urac and TAS-Air metrics which are expensive. As well as these systems have limitations to be installed on chimney due to their principle of operation. In this work I like to propose a function that is easy to use and causes less cost compared to the other ones. That is an industrial air pollution monitoring system based on the technology of Wireless Sensor Networks (WSNs). This system is integrated with the Global System for Mobile (GSM) communications and the protocol it uses 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. It is used to monitor Carbon Monoxide (CO), Sulfur Dioxide (SO2) and dust concentration caused by industrial emissions due to process.

Keywords: Object detection model, Neural network, Deep learning, Python.

1 | Introduction

As there is increase in number of industries and urbanization process all over the world, so because of this environmental pollution is now a common problem in most of the countries. Environmental pollution doesn't only mean of problem it consists of air pollution, water pollution and soil pollution [1]. Air pollution-it can be defined as the presence of contaminants or pollutants in the air that interfere with human health, or produce other harmful environmental effects [2]. These pollutant substances usually result from vehicle emissions, industrial emissions. Air pollution causes different kinds of health issues like difficulty in breathing, coughing and aggravation of existing respiratory and cardiac conditions [3]. The world health organization states that 2.4 million people die each year from causes directly attributable to air pollution, with 1.5 million of these deaths attributable to indoor air pollution [4]. Based on the fact mentioned above, there is a need to focus on air pollution monitoring activities. Due to the rapid development of communication technology, network technology and remote sensing technology, we can develop or design air pollution monitoring system in wireless mode [5].

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https://doi.org/10.22105/bdcv.2022.334375.1079

Wireless Sensor Network (WSN) have been rapidly developed during recent times. Starting from military to industrial controls and its advantages include various factors like liability, simplicity, and low cost [6]. The WSNs are a kind of networks which consist of large numbers of low-cost, low-power, multi-functional wireless sensors nodes. These wireless sensor nodes, which are small in size, are capable of sensing and reacting to specific physical or environmental conditions, such as temperature, sound, pressure, speed, humidity, and so on [7]. These sensor nodes have the wireless communication ability in short distances and pass their data through the network to their desired locations. In a WSN, the position of wireless sensor nodes need not to be pre-determined, this happens because a wireless sensor node may join in or leave the network very quickly [8]. WSN provides a connection 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. Its characteristics give the WSN a wide range of applications, such as industrial automation, agricultural monitoring, air pollution monitoring, health care, security systems, etc. [9].

1.1 | Network Topology

The network which we used here consists of many nodes which are interacting with each other by transmitting and receiving data over communication channels [10]. The network protocol which we are using for communication is Zigbee. The Zigbee network model can be used for star, tree and mesh topologies as shown in *Fig. 1*.

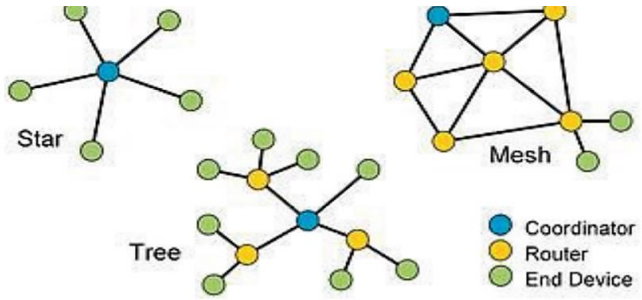

Fig. 1. Network topologies.

The Zigbee Coordinator (ZC) is used to start and maintaining the devices on the network, as well as all other devices. Zigbee End (ZE) devices as well as the routers (ZR), can communicate with the ZC directly that communication depends on the network topology used [11]. While suing 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 [12]. In star topology, all the devices of network are connected to the central device which may be a hub, a router or a switch. All the workstations are connected to central device with a point-to-point connection [13]. So in this every node is indirectly connected to every other node by the help of 'hub'. Depending upon the central device used, hub can act as repeater or signal booster. Central device can also communicate with other hubs of different network [14].

The tree topology is a type of the bus topology. A tree topology combines characteristics of linear bus as well as star topologies [15]. Tree topologies allow for the expansion of an existing network. In a mesh topology, any device is allowed to attempt to contact any other device either directly or by taking advantage of routing-capable devices [16]. The route from the source device to the destination is created on demand and those destinations can be modified if the environment changes [17].

2 | Literature Review

2.1 | Discussion of Existing System

Air pollution control is simply the use to minimize the excess release of harmful chemicals into the atmosphere, as ambient air consists of liquids, gas, and most surprisingly, solids. There are different types of pollution control equipment mainly they can be divided into four main system types: Continuous Emissions Monitoring Systems (CEMS), Emissions control systems, parametric monitoring systems and oxidizers [18]. Each of these functions at their own respective places and minimise the pollution. Brief explanation of the above mentioned methods. CEMS are systems that industry workers use to measure emissions at significant sources of pollution on a regular basis. Emission control systems are air filters systems. Their job is to catch pollutants as they move through them [19]. There are different kinds of emission control systems. Examples include: air scrubbers mist collectors, or control systems and electrostatic precipitators.

2.2 | Benefits of Existing System

I. Air pollution control helps to protect the human health: health is paramount for the running of our day to day activities, without which we would have to rely on others to live. Air pollution scrubber suppliers come to help protect our health, which is very valuable [20].
II. Air pollution control helps prevent economic wastes: with air pollution control, the wastes accrued from dead crops and bad water will be limited or stopped.
III. Increased worker productivity: no matter how strong the immune system is, there are times when it fails, especially when there is excess air pollution. As pollution is controlled, workers can now work for a longer period of time [21].
IV. Helps improve indoor air quality: air pollution control helps to secure the quality of the air inside your house.

2.3 | Disadvantage of Existing System

The cost of the present using techniques in high. As well as the present used is not wireless it is made up of wires and usage of sensors is less. Due to the formation of equipment with wires there is high chance of breaking of wires or cuts [22]. As it is mode up or wires and different machines it can't be places everywhere like in smaller area of cross section.

3 | Proposed System

The system which can be implemented by using wireless sensor that can be using at any parts on the system when observation is difficult and also can reduce the disadvantages caused by the previous systems. The functionality used in this is ZigBee. The specifications are IEEE 802.15.4 standards for low rate personal area networks [23].

3.1 | Zigbee Standard

A Zigbee standard is a short range, low power, and low data rate wireless networking technology for many real time applications. It specifies the three bottom layers, as well as an Application Programming Interface (API) based on the 7-layer open system interconnection model for layered communication systems. It shows the layered architecture adopted by the alliance industries.

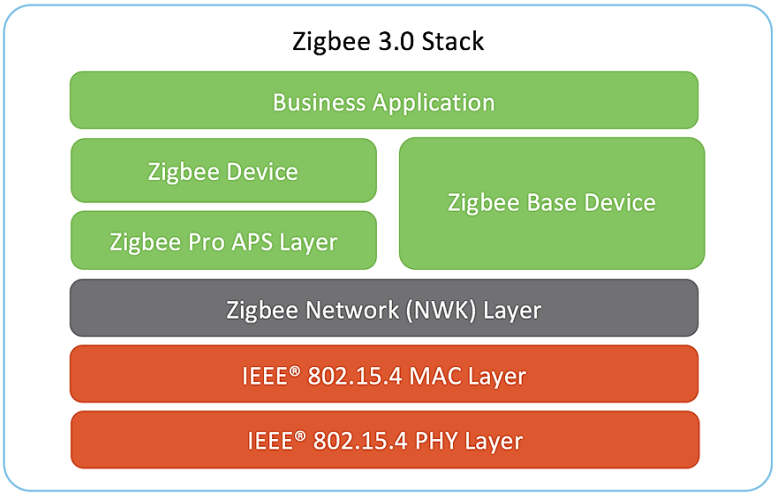

Fig. 2. ZigBee communication layers.

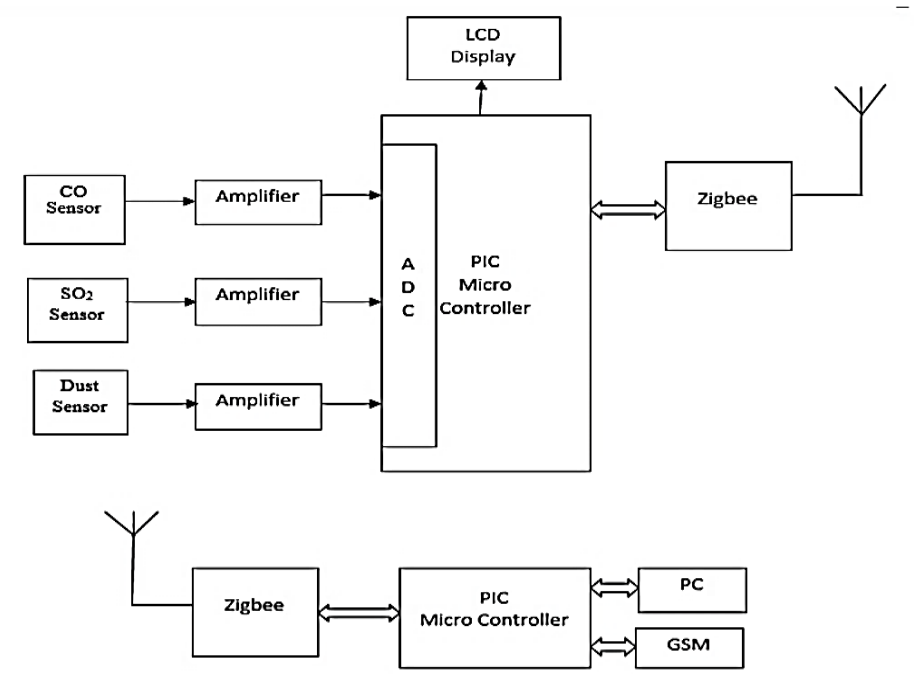

Fig. 3. System hardware architecture block diagram.

3.2 | Zigbee Function

The following formula represents the battery total power consumption of one node of ZigBee network:

$$Pcon = Ptx + Prx + PSleep + Pidle, \quad (1)$$

where

PCon = Total power consumption.

Ptx = Power consumption due to transmitted signal.

Prx = Power consumption due to received signal.

PSleep = Power consumption during sleep state, where the router is in sleep mode.

Pidl = Power consumption due to Idle state, where there is no packets are transmitted or received.

The battery lifetime in hours could be calculated using the following formula:

$$T = \frac{IC}{I^n}, \quad (2)$$

where

T = Battery life time in Hours.

IC = Battery capacity in mAH.

I = Load current in mA.

n = Peukert's exponent, it ranges from 1 to 1.3, where 1 is the nominal value.

4 | Simulation Results and Discussion

The simulations have been performed using the Proteus software and MicroC Pro. for PIC. The designed sensor array consist of CO, SO2, and dust sensors. These sensors are connected to microcontroller. The sensor output voltages representing the level of each pollutant were converted to a mg/m3 value and simultaneously these data are sent to the database to be displayed.

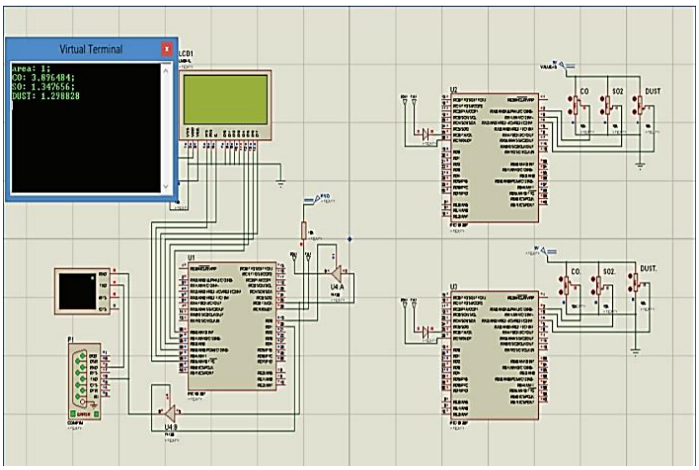

Fig. 4. Pollutant measurement at area.

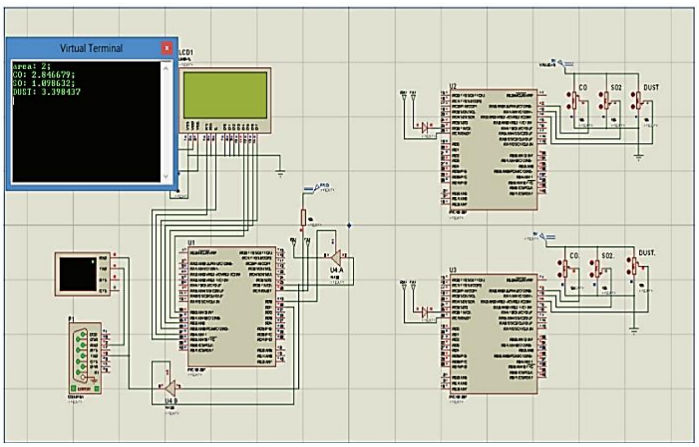

Fig. 5. Pollutant measurement at area 2.

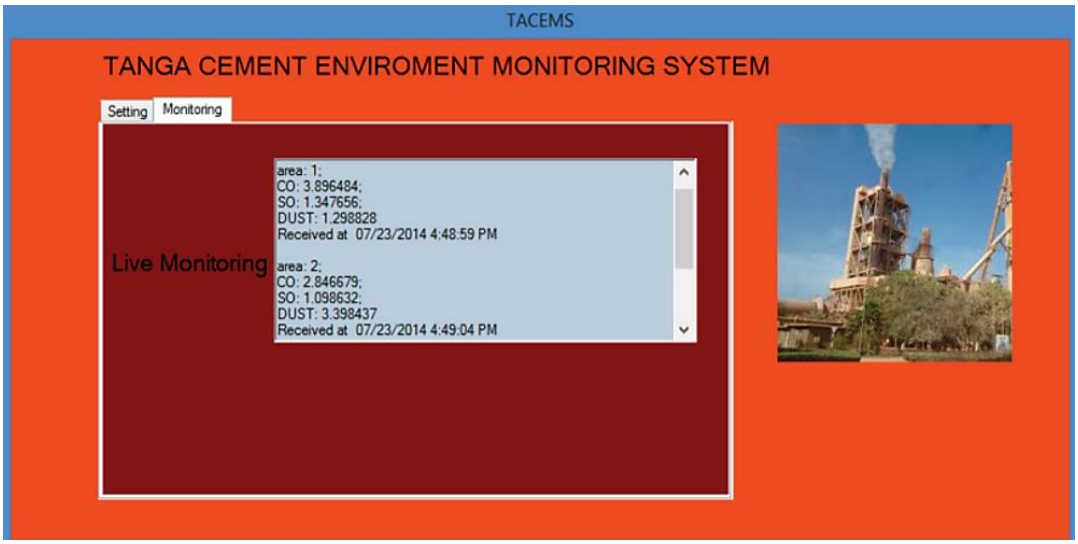

Fig. 6. The live environmental monitoring.

5 | Conclusion

We have designed an air pollution monitoring system based on wireless networks by using Proteus software to provide live monitoring and measure harmful air pollutants. Our system has been designed specifically in the context of cement factories, particularly for those in Sub-Saharan countries where there is a lack of technologies in environmental monitoring because most of industries are using wired and traditional systems

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