Monitoring Air Pollution using Tree-Based Routing Scheme for Wireless Sensor Nodes

V. Shilpa[1] Dr. A. Kumar Kombaiya[2]
[1]M. Phil Research Scholar [2]Assistant Professor
[1,2]Department of Computer Science
[1,2]Chikkanna Government Arts College, Tirupur, India

Abstract— The air quality in urban areas is a major concern in modern cities due to significant impacts of air pollution on public health, global environment, and worldwide economy. Recent studies reveal the importance of micro-level pollution information, including human personal exposure and acute exposure to air pollutants. Environment pollution is one of the major aspect and ambient air quality monitoring is essential to determine the existing quality of surrounding air, which is polluted by industrial sectors. Hence, present system is designed for monitoring of industrial environmental parameters. The system consists of a base station, gas sensing nodes, a tree-based routing scheme for the wireless sensor nodes and a real-time monitoring application that operates from a remote computer and a mobile phone. The system has been designed to be easily scaled-up to measure other parameters of interest. All aspects of the monitoring system such as sensing activity, transmission from sensor nodes to base station, remote transmission from the base station to the control center or information management system, data storage, and visualization, have also been designed and implemented.

Key words: WSN, Air Pollution, Monitoring System & Tree-Based Routing Scheme

I. INTRODUCTION

Air pollution is one of the most important factors affecting the quality of life and the health of the increasingly urban population of industrial societies. In many cities, the air is polluted by emissions from sources such as cars and trucks, power plants, and manufacturing processes. When gases and particles from those activities accumulate in the air in high enough concentrations, they can be harmful for human health, an environment. Often, terrain and meteorological conditions complicate air quality issues in the area [1]. Although the national trend is toward better outdoor air quality, there are some urban areas in which no improvement has taken place. Concentrations of outdoor air pollutants vary from day-to-day and even during the course of a day. For health protection, the public needs timely information about air quality and other factors (e.g., weather conditions) that affect it. An access to air quality forecasts allows residents to reduce their exposure when the pollutant concentrations are high. To monitor the pollution WSN provide a better monitoring mechanism [2]. It helps to monitor the pollution in industrial society and in any area. Wireless Sensor Networks are grooming technology successfully applicable to monitoring Air Quality, Habitat, Water Quality, Volcano eruption, forest fires, landslides, biodiversity etc.

Wireless sensor networks are made of by a collection of small electronic based devices named as Sensor Nodes or Motes, which are able to aggregate information from targeted area by transducers and it, transmit aggregated information to Sink Node using Wireless communication with appropriate Routing technique [3]. After information processing and handling, data is stored to database system or Server to use it for further preventive, decisive actions and analysis. Basically, Wireless Sensor Network consists of four constructive subsystems Sensor Nodes, Router, Sink Node or Gateway, Information Management-Processing Unit (IMPU). Wireless sensor networks (WSN) have emerged as one of the most promising technologies for the future. Some of the potential application domains are healthcare, army, environment and agriculture, industry, transportation systems and security [4]. Unlike other networks, WSN are designed for specific applications, and thus, they must satisfy a set of requirements that differs from one application to another. Therefore, researchers must address a variety of challenges to facilitate the widespread deployment of WSN technology in real-world domains. As a result, great efforts have been devoted to overcome the energy-saving problem and reliability [5]. Some of the application areas are: Environmental/Earth sensing, Area monitoring, Health care monitoring, Forest fire detection, Water quality monitoring, Air pollution monitoring, Landslide detection, Natural disaster prevention, Industrial monitoring, Machine Health Monitoring and many more [6]. Air pollution monitoring is extremely important as air pollution has a direct impact on human health and environment. In this paper we propose a wireless sensor network system for participatory air pollution monitoring. The system consists of a base station, gas sensing nodes, a tree-based routing scheme for the wireless sensor nodes and a real-time monitoring application that operates from a remote computer and a mobile phone. The system has been designed to be easily scaled-up to measure other parameters of interest. All aspects of the monitoring system such as sensing activity, transmission from sensor nodes to base station, remote transmission from the base station to the control center or information management system, data storage, and visualization, have also been designed and implemented. The traditional air quality monitoring system, controlled by the Pollution Control Department, is extremely expensive. Analytical measuring equipment is costly, time and power consuming. In contrast to traditional air pollution monitoring stations, we present the design, implementation, and evaluation of low power, low cost WSN based Air Pollution Monitoring System which provides real time monitoring of polluted materials at proper locations by using distributed (real time) air pollution monitoring systems. Sensor networks are used in many fields and have been deployed in a variety of applications ranging from monitoring a small room to the large area. In future multiple base stations (BS) and periodically transmits data over a short distance to a base station will lead to control the pollution.

II. LITERATURE REVIEW

Bhavika Bathiya [7] Rapid urbanization and industrialization has resulted in a sustained degradation of environmental quality parameters. It is important to keep track of various environmental pollution indices so that realistic models can be developed and relevant public policies are created. Traditional methods for air pollution measurement are expensive and have a spatial constraint. With these limitations, air pollution monitoring in broader area is not feasible. However, use of modern low-cost sensors in conjunction with wireless sensor network (WSN) creates an opportunity to collect real time data from different locations and provide detailed pollution map. The main aim of this project is to develop a low cost multi-sensor node for air pollution measurement, and to develop WSN protocols for data gathering and data aggregation protocol. We have designed and fabricated such a board. To maintain data accuracy, calibration of each sensor is performed by comparing data transmission using any of the multiple radio technology with fault-tolerant topology control

Bhagyashree Mohanta [8] A forest fire is a disaster and threat not only to the forest but also to the wild animals, the entire ecology and to the environment. The early detection and monitoring of forest fire with accuracy leads to a boon to the wild life and the inhabitants because, as soon as the detection and monitoring is processed, the necessary and quick actions to that can be taken in time. In this paper we explore the use of wireless sensor network (WSN) for real-time monitoring of forest fire. The objective of this paper is to detect and forecast the information regarding forest fire efficiently and cost effectively, so that the losses to forest wealth, its inhabitants and to the environment can be optimized. Forest fire is considered to be one of the serious issues for different countries. So they are interested in investing and promoting R & D activities in order to prevent this tragedy. In this paper we discuss various aspect of wireless sensor network in forest fire detection since WSN is considered to be real-time, cost effective and energy efficient model. The practical implementation of our above proposed model is in rigorous progress

Elias Yaacoub, et al [9], In this paper, an actual deployment of a wireless sensor network is described. The purpose of the sensor network is to monitor and analyze air quality in Doha. Small scale wireless sensor stations communicate with a backend server to relay their measurements in real-time. Data stored on the server is subjected to intelligent processing and analysis in order to present it in different formats for different categories of end users. This paper describes a user friendly computation of an air quality index to disseminate the data to the general public. In addition, it describes data presentation for environmental experts using dedicated software tools, e.g. the R software system and its OpenAir package. Analysis and assessment of real measurement data is also performed in the paper.

Wei Ying Yi [10] The air quality in urban areas is a major concern in modern cities due to significant impacts of air pollution on public health, global environment, and worldwide economy. Recent studies reveal the importance of micro-level pollution information, including human personal exposure and acute exposure to air pollutants. Currently, researchers focus on the concept of The Next Generation Air Pollution Monitoring System (TNGAPMS) and have achieved significant breakthroughs by utilizing the advance sensing technologies, MicroElectroMechanical Systems (MEMS) and Wireless Sensor Network (WSN). However, there exist potential problems of these newly proposed systems, namely the lack of 3D data acquisition ability and the flexibility of the sensor network. In this paper, we classify the existing works into three categories as Static Sensor Network (SSN), Community Sensor Network (CSN) and Vehicle Sensor Network (VSN) based on the carriers of the sensors. Comprehensive reviews and comparisons among these three types of sensor networks were also performed.

III. PROBLEM IDENTIFICATION

Wireless sensor networks are currently an active research area mainly due to their several applications. In this paper they describe the use of Wireless Sensor Networks (WSN) for air pollution monitoring system. With the fast growing industrial activities the problem of air pollution is becoming a major concern for the health of the population. They proposed an innovative system named Wireless Sensor Network Air Pollution Monitoring System (WAPMS) to monitor air pollution through the use of wireless sensors deployed in huge numbers. They used a hierarchical routing protocol in WAPMS this proposed system makes use of an Air Quality Index [11]. The drawbacks of the conventional monitoring instruments are their large size, heavy weight and extraordinary expensiveness. These lead to sparse deployment of the monitoring stations. In order to be effective, the locations of the monitoring stations need careful placement because the air pollution situation in urban areas is highly related to human activities (e.g., construction activities) and location-dependent (e.g., the traffic choke-points have much worse air quality than average). Changes in urban arrangement, activities or regulation may affect both the species and the concentrations of air pollutants, which require relocating stations or adding new stations. These requirements are typically hard or even impossible to fulfill due to the cost inefficiency in acquisition and maintenance of the monitoring stations.

IV. PROPOSED METHOD

Wireless Sensor Network (WSN) monitoring system is designed for the structural health monitoring Air pollution. Recently, air pollution monitoring emerges as a main service of smart cities because of the increasing industrialization and the massive urbanization.

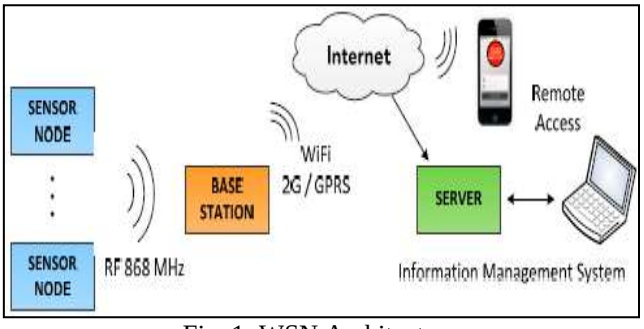

Fig. 1: WSN Architecture

Wireless sensor networks (WSN) are a suitable technology for this purpose thanks to their substantial benefits including low cost and autonomy. Minimizing the deployment cost is one of the major challenges in WSN design, therefore sensors positions have to be carefully determined. The proposed system can be easily scaled up equipping various sensors on the designed sensor node or even including new sensor nodes to measure other physical magnitudes or parameters of interest. The wireless transmission was used to integrate all independent sensor signals that allowed for centralization and real-time control. Central management saves labor, increases efficiency and greatly reduces costs in industrial safety. The network is established in star protocol and the site specific data is demonstrated at the Base Station.

A. Data Processing

The objective is to display the collected and processed information in a user-friendly format. A website and mobile application are developed to display the real-time measured data in addition to reports containing historical summaries of previous measurements. The website allows displaying the positions of the MG monitoring stations on a map. Clicking a particular station enables a pop-up window that shows the most recent measurements at that location [12] In addition to this map view, the website provides a tabular view where the measurements of all stations are listed. In addition, a report view provides detailed reports and statistics about the pollution levels of the different gases. Data processing helps to analyze the pollution in an area.

B. Information Management System

Several system status data need to be defined and gathered together with the sensor data. Moreover, it is important to remotely adjust system configurations and update and upgrade software programs. In addition, remote monitoring of system status is useful for system development, debugging, and maintenance purposes. The information management system includes a web application and mobile applications for iOS and Android, which allow the control of all system parameters, and monitoring alarms and events. The web application allows configuring the system from a remote computer via Internet by authorized users, accessible through the outer communication system [13, 14]. The mobile application also provides alerts in real-time. The complete monitoring and control for industry applications involves the measurement of several physical magnitudes to improve the quality of the processes. The designed wireless system is scalable, and thus the number of quantities to be measured is easily expandable.

C. Tree-Based Routing Scheme

Tree Based Routing Scheme has been deployed so that the sensor nodes (acting as End Devices) can be set as reduced-function devices (RFD) with the ability to enter in the sleeping mode in which the consumption can be considered negligible [15]. Sensor nodes could act as a full function device (FFD) or RFD. In FFD, the nodes never sleep, as they need to relay the information from the RFD to the sink node, while a RFD will only wake after a certain period of time to: gather the sensor data, forward it to a FFD node and go to the sleep mode. To this aim, sensor nodes are deployed with a cluster-tree topology.

1) FFD

Full Function Device - a node that has full levels of functionality. It can be used for sending and receiving data, but it can also route data from to her nodes.

2) RFD

Reduced Function Device - a device that has a reduced level of functionality. Typically it is an end node which may be typically a sensor or switch. RFDs can only talk to FFDs as they contain no routing functionality. These devices can be very low power devices because they do not need to route other traffic and they can be put into a sleep mode when they are not in use.

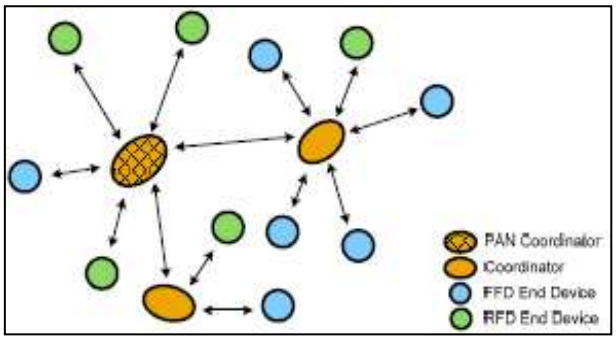

Fig. 2: Tree Routing Scheme

Both the employed network topology and the protocol allow the designed system to increase its scalability, containing a large number of sensor nodes. In this way, low cost and small-sized sensor nodes have been implemented. Finally, latency has also been taken into account for practical operation. Latency is an important factor for the system reliability such as in the case of emergency response, and accuracy of data reporting in case of high frequency periodical data updates. The communication of asynchronous events, such as the reception of new messages or network outage is performed through a set of callbacks added to the APIs of each layer. This structure (although the development has been somewhat more complex than in the case of stacks as in MiWi) has allowed to reduce the maximum processor usage, and the stack scarcely influences the other components of the nodes. Our proposed system provide the advantage of the power consumption is also reduced because the CPU is free a longer period of time.

V. EXPERIMENTAL RESULT

We conducted a thorough experimental evaluation of the proposed techniques through dataset. By means of this software, real time monitoring of physical magnitudes and battery level of all active nodes can be done. Furthermore, all information measured by the nodes can be preserved for further processing. This information allows the user to act on the system at any time. The web and the mobile applications allow the user to configure all devices of the wireless system, as well as monitoring and receiving alarm warnings. Designing the energy efficient software algorithms, protocols and developing the energy-efficient scalable hardware architectures are the critical challenges for the researchers in this domain. Sensors operate on the batteries and energy is consumed in data collection, data processing, and data

communication and also in idle condition. Regularly batteries are needed to be replaced or recharged after they have been drained out. It is difficult sometimes to restore or replace the batteries because of demographic conditions.

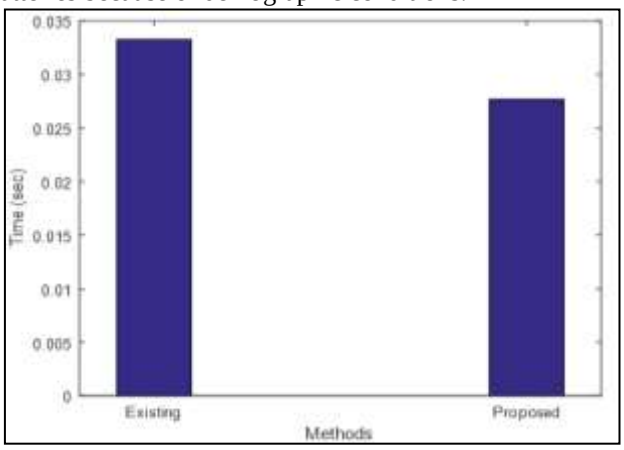

Fig. 3: Accuracy Difference

When compared to existing system time consumption of analyzing was reduced by the control of air pollution.

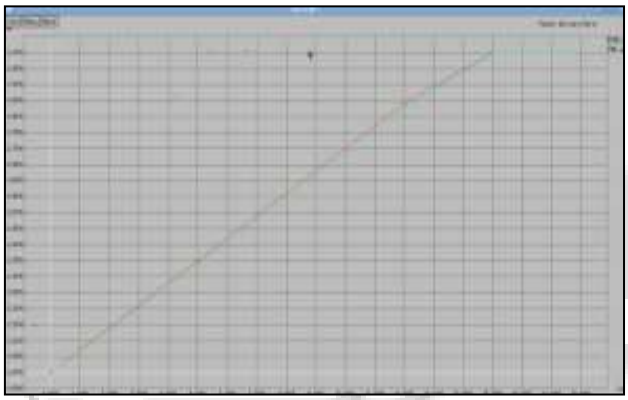

Fig. 4: Monitoring Data

This system consists of Air Pollution Index (API). It provides a range of the air which were polluted by the society. It gives the quality of the air in the range of 1 to 500 at a particular location.

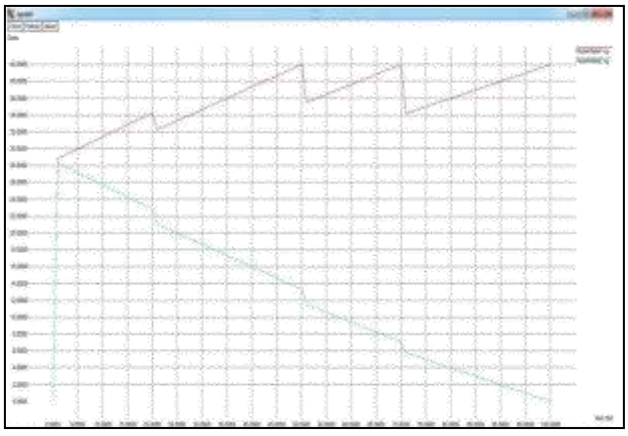

Fig. 5: Storage Usage

Figure 5 shows that the data were stored in a server to view the polluted quality. Air quality is good and no health hazard when the AQI value is between 0 to 50.

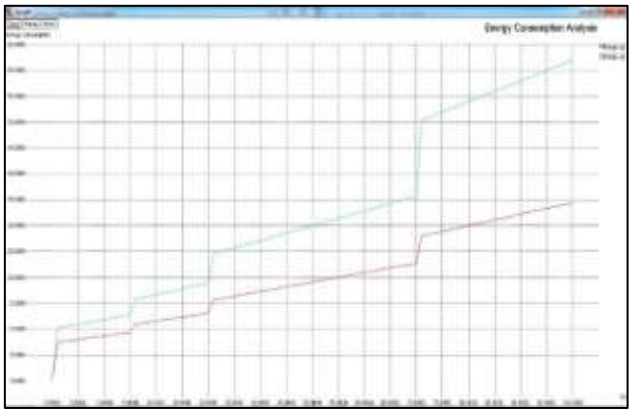

Fig. 6: Energy Consumption

Energy consumption is less when compared to the existing hierarchical routing protocol in WAPMS. It consume less energy to analyze the air quantity.

VI. CONCLUSION

WSN based Air Pollution Monitoring System which provides real time monitoring of polluted materials at proper locations by using distributed (real time) air pollution monitoring systems. We proposed a Tree-Based Routing Scheme to monitor the air pollution in an industrial area. The proposed system can be easily scaled up equipping various sensors on the designed sensor node or even including new sensor nodes to measure other physical magnitudes or parameters of interest. The wireless transmission was used to integrate all independent sensor signals that allowed for centralization and real-time control. Central management saves labor, increases efficiency and greatly reduces costs in industrial safety.

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