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Smart Environment Monitoring System by employing Wireless Sensor Networks on Vehicles For Pollution Free Smart Cities

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Abstract

With the progression of advancements in technology, several innovations has been made in the field of communications that are transiting to Internet of Things. In this domain, Wireless Sensor Networks (WSN) are one of those independent sensing devices to monitor physical and environmental conditions along with thousands of applications in other fields. As air pollution being a major environmental change that causes many hazardous effects on human beings that need to be controlled. Hence, we deployed WSN nodes for constant monitoring of the air pollution around the city and the moving public transport buses and cars. This methodology gave us the monitoring data from the stationary nodes deployed in the city to the mobile nodes on Public Transport buses and cars. The data of the air pollution particles such as gases, smoke and other pollutants is collected via sensors on the Public transport buses and the data is being analyzed when the buses and cars reach back to the source destination after passing through the stationary nodes around the city. Our proposed architecture having innovative mesh network will be more efficient way of gathering data from the nodes of WSN. It will have lots of benefits with respect to the future concept of Smart Cities that will have the new technologies related to Internet of Things.

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1. Introduction

Wireless sensor networks (WSNs) consist of small autonomous nodes that have the benefits of being small, efficient relatively low in price. Sensor networks have major application of real-time monitoring. Latterly, the progress on sensing, processing and communication technologies have reduced the cost of sensors, made them smaller in size and power efficient. However, the system performances of WSNs are still subject to unit computing speed, memory capacity and stability of communication, etc. Together the limitations of hardware, many issues on WSNs software have been discussed, such as routing protocols, media access control [1], coverage and power management.

WSNs have several advancements in this era from design to its operations and later with passage of the time few enhancements were added up. Sensor networks resilience and energy effectiveness are compulsory. Alterations are required to increase the lifetime of WSNs within the network, whether it should be in design and upgradation in devices. Wireless sensor networks are accustomed to monitor the traffic congestion, timely disaster warnings, home and Medical applications etc. Wireless Sensor network is comprised of huge number of sink nodes, sensors nodes and communication connectivity among these devices that is installed on the ground, with in building and vehicle etc. A sensor node is fabricated of independent components such as transmitter, data processing essentials, receivers and energy source. Sensor node is responsible to send information detected by its sensing abilities to subsequent sensor node or to sink node. Diverse Parameters of environment are measured by sensing component of wireless sensor network such as gases, smoke concentration, and dust particles etc. [2]. That causes air pollution. Computation system executes the process of data collection.

With the increasing level of air pollution and gases there becomes the need of the monitoring of the indoor air pollution to save more human lives. It has been researched as people are dying more because of the because of the presence of indoor Volatile Organic Compounds (VOC), therefore we need to put more focus on saving the indoor air pollution along with the outdoors. For this purpose, we have developed the proposed model for the Indoor and outdoor hazardous gases by using Wireless Sensor Networks.

Structure of Wireless Sensor Networks

A	Communication Part
B	Memory Region
C	Sensor Node

1.1. Environmental Pollution

Generally, the environmental pollution or changes has been defined as presence of substances in the environment that can causes instability,disorder,harmor discomfort to the physical systems or living organisms. Environmental pollution consists of hazardous gases, polluted water along with other agricultural pollutions that are harmful for the crops. This paper is based on saving from air pollution that has the major cause of many health issues in human beings. Air pollution that majorly is the presence of contaminants in the form of different hazardous gases, chemical substances and dust particles in air that causes dangerous damages to human health and produce other harmful environmental effects. These polluted substances usually result from vehicles and Industrial emissions and volatile organic compounds. Air pollution is one of the major issues for health of humans, so clean air is basic necessity for good health. The World Health Organization states that 2.4 million people die each year from causes directly attributable to air pollution, with1.5million of these deaths attributable to indoor air pollution [3]. Based the fact above mentioned, we focused on air pollution monitoring around metropolitan and industrial cities in Pakistan by using Zigbee based Wireless Sensor Networks while deployed on Public Transport vehicles.

The hazards for Air Pollution is as follows:

- Global Warming
- Health Hazard

2. Proposed Method of air pollution monitoring for both indoor and outdoor purposes

In most of the sensor networks [4], few nodes act as intermediate or data collecting node, that collects the data and to transfer that to sink node for processing. So there is a need of an efficient routing algorithm so that the data could transmit to sink node in smaller time. Considering a case if bulk of data from the sensors has been collected and the routing algorithm is not environment friendly along with not as much intelligent to distribute the bandwidth in more efficient way then the system will not work properly and it would be expected to deliver the wrong information. Therefore, we have proposed a model that doesn't require the complex routing algorithm rather the sensor nodes will be deployed and get connected to other sensor nodes and sink node in much easier way. We have also proposed the technique that we used in the network for collecting the data. There are indoor and outdoor units that worked on different protocols and then data is being collected in the cloud for big data analytics.

For some testing, we have deployed mobile sensor nodes on the public transport vehicles mainly called as Metro Bus Service that is actually moving around the city and covering all the major areas of the city. These public transport vehicles pass through different areas in which concentration of air pollution is different from each other area. Moreover, these sensor devices can also get the data of other environmental parameters including the passenger's information, intelligent transportation and many other useful information. For example, the nodes employed on vehicles.

Figure 1. Sensor Nodes on Public Vehicles Collecting Data from different Stationary Nodes at difference locations

For collecting the data of Smoke, dust and other gases in the environment which causes air pollution, these mobile nodes that has been deployed on public transport vehicle collects data when goes in the range of the coordinator node which is also connected to the other stationary nodes nearby, and continuous sensing the concentration. On the other hand during the whole pathway from where Public Transport vehicle passes, we installed node sin a way that a cluster is formed up in the specific areas [5]. These clusters have been developed to measure the concentration of air pollution in specific areas, so that necessary action will be taken on specific areas where air pollution has larger concentration. Sensor nodes are smaller in sizes deployed in numbers around the metropolitan city. We proposed the architecture having one sink node in each cluster of the sensor nodes. By using the technique of homogeneous communication network, we may have the less number of nodes in larger area in the city [6]. Using those sensors deployed in the highly dense and less dense areas in a star network from having connection with moving node on Public Transport Vehicle directly when it comes in the range of cluster head (Sink Node). While using the technique of deploying the cluster and a sink node in this way we will be able to collect the current data of the specific place and can be able to analyze that accordingly in more convenient way. Secondly intermediate node (extra overhead off or warding information) to coordinator must be avoided. Intermediate nodes loss up the connection then all routes via that nodes also crashes in normal network[7]and in that scenario network badly suffers, so such problem didn't arises in said scenario there is a direct link between sensor node and cluster

head[8]. Finally, when Public transport vehicles reaches back to destination, we collected the data collected by routing nodes deployed on metro bus service during the whole pathway of. Metro Bus Service. Then we analyzed the data and collected information and found where the concentration of smoke, carbon oxides and other gases and other dust particles were in concentration.

By using the wireless sensor network architecture module, we can then be able collect the data for analyzing through some web server and other web based services that will display the data. Our proposed system architecture has Wireless Sensor Network, web server and web services provider that will help in managing the data collected through different nodes. The following is a description of the system architecture through which we can detect and analyze the data.

3. Architecture and Future Technology of Network System based on Wireless Sensor Network and LTE-M

For collection of data the analogy which we proposed is based on LTE-M, which is future oriented technology, low power consumption specifically designed for long range coverage and millions of connections available for mobility architecture and low data rate. This technology will exist in the outdoor units (Buses) which is based on mobility and will be deployed on moving buses. When buses will stop on the stations where Zigbee wireless sensors as a fixed network been deployed then the modules of LTE-M will collect data from Zigbess Wireless Sensors and will send it to the cloud where it will be analyzed accordingly. The reason to use LTE-M is to make convenient for future technologies in Smart cities that will also be useful and compatible with the LTE-M. Figure 2 shows the architecture of LTE-M.

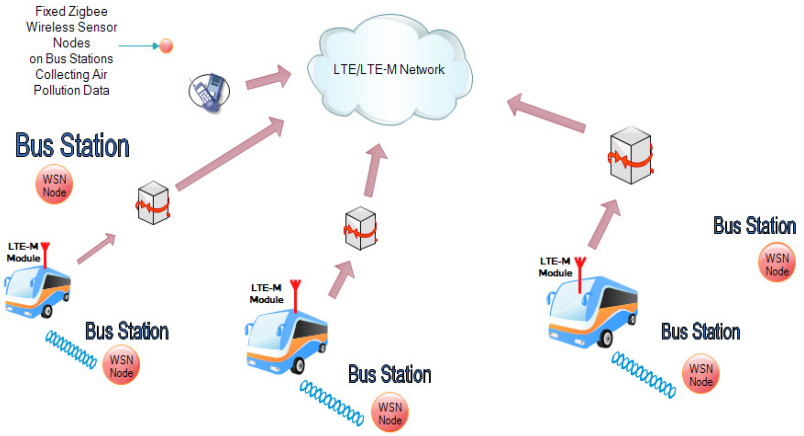

Figure 2. LTE-M based Outdoor (On Public Vehicles) Network System Architecture

Moreover the indoor unit that will be deployed in the Bus Stations will be based on Zigbee Wireless Sensors that will connect with the LTE-M modules and data will be collected when each bus will stop on the station and that is how we will collect the data.

Figure 3 illustrates the WSN system. As shown in Figure 3, we can collect and analyze the data in a way that the sensor node collects the data from the air, it transmits the data to the sink node of the cluster. Then sink node will collect the information through all sensors and make a database. After the public transport buses will reach to the destination we can collect the data either using direct USB or Ethernet that helps us in connecting with the Server that will actually make a database management and makes the data readily available to be displayed through Internet using any web based device connected to the internet. Whenever the updated data is needed the server will request the data form the sensor devices and in that way we can collect the data in more easy way. For Indoor purposes, there has been several test performed and data has been measured accordingly, such as reaction time test, sensitivity test, humidity test and paint test. The test results show that we can able to control the indoor air pollution by using that methodology.

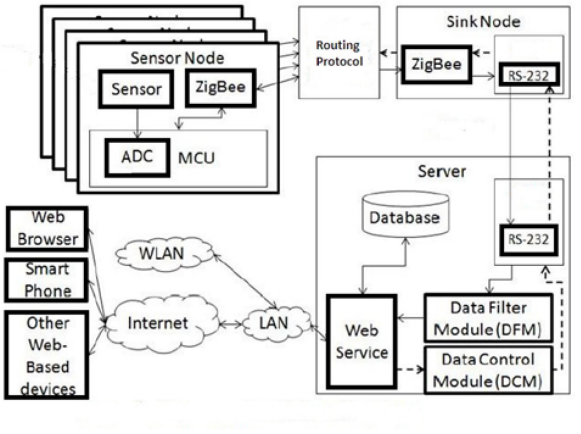

Figure3. Wireless Sensor Network System Architecture

4. Conclusion

Previously the issue has been discussed among various places but solutions were quiet expensive that led to difficulties in implementations. This time we have also introduced the concept with the inclusion of the Internet of Things and LTE-M modules that are low cost and more efficient system for M2M devices, which will be helpful for many other aspects and can be supportive enough to propagate other technologies for several other applications in making the smart cities. So as discussed, one major concern of optimal deployment of sensor node power is addressed and planned solution and endeavor was to introduce new way of collecting data of air pollution by the help of Public Transport vehicles to save time and energy, also reducing the handing out of every sensor nodes. We suggested a method where these sensor nodes can directly communicate with the moving nodes deployed on the public vehicles in this paper. Thus it will diminish the requirement and processing (routing algorithm) for special connectivity. As a consequence it results in long-term and increasing reliability and durability of each of the sensor nodes and data security. Extension of this work for better communication mechanism between coordinator nodes will be effective one. Scheme of base station for better pollution calculation for cluster will help to make technology environment friendly.

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References

[1] Stojmenović I, Handbook of sensor network, 1st ed. Ottawa: John Wiley & Sons, 2005).
[2] Jong-Won Kwon,Yong-ManPark,Sang-JunKoo,Hiesik Kim, Design Of Air Pollution Monitoring System Using ZigBee Networks for Ubiquitous-City,in Proceedings of the 2007 International Conference on Convergence Information Technology.
[3] http://en.wikipedia.org/wiki/Air_pollution,Wikipedia.
[4] David Fotue, Guy Tanonkou and Thomas Engel, “An ad-hoc Wireless Sensor Networks with Application to Air Pollution Detection".
[5] Kiran Maraiya, Kamal Kantand Nitin Gupta,"Efficient Cluster Head Selection Scheme for Data Aggregation in Wireless Sensor Network”, International Journal of Computer Applications (0975–8887), Volume 23–No.9, June 2011.
[6] Qingping Chi, Hairong Yan, Chuan Zhang, Zhibo Pang, and Li Da Xu, “A Reconfigurable Smart Sensor Interface for Industrial WSN in IoT Environment”, IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS, VOL. 10, NO. 2, MAY 2014.
[7] Le Zhang “An IOT System for Environmental Monitoring and Protecting with Heterogeneous Communication Networks” 2011 6th International ICST Conference on Communications and Networking in China (CHINACOM).
[8] Amnesh Goel, Sukanya Ray, Prateekand Nidhi “Air Pollution Detection Based On Head Selection Clustering and Average Method from Wireless Sensor Network” IEEE 2012 ICACCT.