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Ubiquitous Wireless Sensor Networks for Environmental Monitoring in the Western Himalayan Region of India

Dhirendra Sharma
University Institute of Information Technology, H.P. University, Shimla 171 005, India

Vikram Kumar
University Institute of Information Technology, H. P. University, Shimla 171 005, India

Marco Zennaro,
Telecommunication/ICT Development Lab ICTP, Trieste, Italy

Abstract - Ubiquitous Wireless Sensor Networks (UWSN) has emerged as a most powerful and efficient tool for monitoring, assessing and managing the environmental pollution related issues particularly in getting the real time data from widely spread locations, to a centralized location, which is not possible otherwise. Wireless Sensor Networks has also been widely used by military, security agencies, industries, healthcare monitoring systems and even for managing, to some extent, the manmade/ natural disasters. During the past few years, the state of Himachal Pradesh, located in the Western Himalayan region of India, has made remarkable progress in developing new industrial areas with growing population along traffic startups having a good network of transport infrastructure. Such a growth in new industrial establishments has opened up growing opportunities for the people living in this area, but at the same time a significant increase in the pollution level has also been noticed in the environmental air as well as in water posing a serious threat to the habitants. This conceptual paper presents a solution for monitoring air pollution to acquire real time values in the state of Himachal Pradesh, India. A successful implementation of Ubiquitous WSN and its connectivity with the Himachal State Wide Area Network (HIMSWAN) will help in analyzing air pollution parameters in a better way by collecting the real time data from the widely spread locations at a central location, analyzing it and then generating the forewarning for the people of the state.

Keywords: Ubiquitous Wireless Sensor Network (UWSN), WSN, SWAN, Air Pollution monitoring

I. INTRODUCTION

With the advent of the wireless sensor networks a great ray of hope has emerged to find a solution for the long lasting and critical problem affecting the life of common man. Today, the latest ICT enabled technologies have made the life very comfortable in the age of great industrialization. It seems to be a matter of pride to feel that latest technologies are very much within the reach of a common man. But, the other side of this growth is very hazardous. Due to the rapid and intense industrial development in the country, growing traffics, high rate of migration of population to the urban areas, high levels of energy consumptions, unplanned and fast urban growth, the economic development has lead to higher rate of increase in air pollution in those areas. Another dark side is that, we are not fully equipped with the latest technologies/ systems, which can provide the real time analysis of the data and guide in advance to deal with the situation. The current status is, having understood the crucial nature of the pollution, a study of air pollution, level and its growth in the last six years had been carried out in Shimla – the capital of Himachal, Pradesh located in Western Himalayan region of India and is popular as the best tourist destination. In this state, a pollution control board is in existence/ working, with a mission, 'To improve the well being of the people of the state through environmental interventions', and to deal with the issues related with pollution in the entire state of Himachal Pradesh, India. H.P state pollution control board is trying to measure each of the various aspects of pollution and reporting this to the concerned agencies. A technology used to measure different aspects does not cater to the needs of current requirements. A lot a manual work and processing is involved to generate some relevant information and still the real time data and its analysis is not available about the air pollution. Ubiquitous Sensors Networks (USN) [1] has emerged as a ray of hope to provide solution to these problems. e.g. Community sensor networks [2]. Developments like "Sensor-Internet Share and Search" [3] and "People - Centric Urban Sensing networks" [4] are great examples of advancement in this area.

This conceptual paper is an attempt to present a possible solution to various problems related to the monitoring of air pollution with the use of wireless sensor network.

II. PRESENT SCENARIO OF AIR POLLUTION IN SHIMLA

The World Health Organization (WHO-1999) has defined "Air pollutants" as substances put into air by the activities of mankind, in such concentrations, which are sufficient to cause harmful effect to human health, vegetation, property or to interfere with the enjoyment of property.

Air pollutants change the composition of the atmosphere and affect the biotic environment. Some of the pollutants of concern are particulate matter (smoke, fumes etc); oxides of carbon, nitrogen and sulphur; hydrocarbons; metals;

oxygenated compounds (alcohols, aldehydes, acids, etc.); ozone and other oxidants etc. Two general groups of pollutants, based on their nature of formation, have been identified, viz. primary pollutants and Secondary pollutants [5].

- Primary pollutants are those that are directly emitted from the source e.g., Sulphur dioxide (SO2), Nitric oxide (NO), Carbon monoxide (CO), etc.
- Secondary pollutants are those that are formed in the atmosphere as a result of reactions between normal air constituents and primary pollutants or amongst primary pollutants only, such as Sulphur trioxide (SO3), Nitrogen dioxide (NO2), Peroxy acyl nitrate (PAN), etc.
- Another classification of pollutants depending on their nature defines two kinds of pollutants, viz. critical pollutants and hazardous air pollutants. Oxides of sulphur and nitrogen, carbon monoxide, ozone and suspended particulate matter are some of the 'critical pollutants'.
- Most of the pollutants, related to petroleum production, processing and use, have an intrinsic toxic potential which fall in the 'Hazardous Pollutants' category. Their products as a result of photochemical reaction are more dangerous than the original pollutants and may affect biological systems at extremely low concentrations

Being a very popular tourist destination, Shimla in Himachal Pradesh has a lot of environmental disturbance due to a large number of tourists coming to this area. Air pollution data [6] for the last six years of this city under study has been presented below for two different sites in Shimla. Site -1 (Fig -1a), is located near the Inter State Bus Terminal of Shimla. The other site – 2, (Takka bench), is situated on the main ridge of the city, where no traffic is allowed, Fig 1(b). Fig 1(c), presents the month wise air pollution data for year 2009 -10.

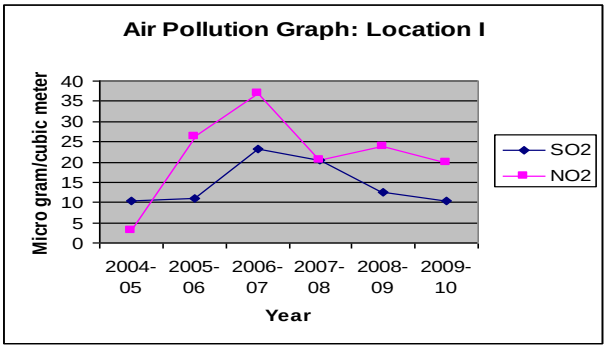


Fig. 1(a) Air Pollution Graph: Location-I

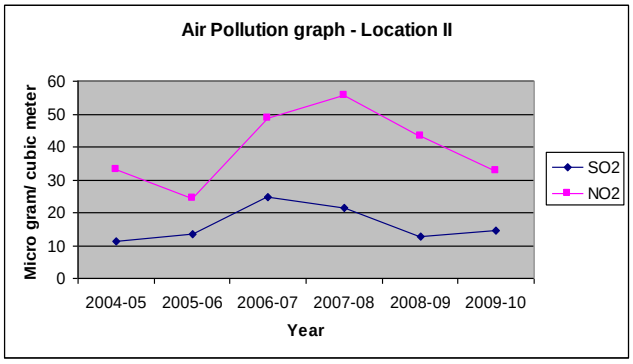
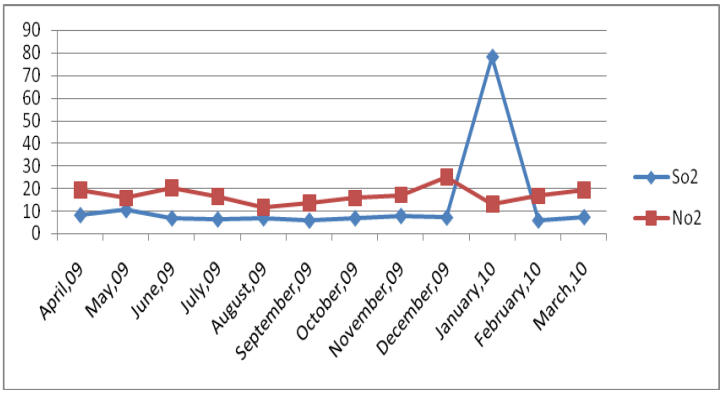


Fig. 1(b) Air Pollution Graph Location II



ig. 1(c) Month wise air pollution data for year 2009 -10.

From Fig 1(a), Fig (b) and Fig 1(c), following observations are made:

- There is a significant increase in the pollution from the year 2004 to 2006.
- A significant control over the air pollution level can be seen after year 2006 -07.

- In comparison to the national quality standards, it can be concluded that still Shimla city is quite safe and pollution free.
- From the month –wise plot, November to March 2010 is a peak winter season for the tourists in Shimla, accordingly highest level of air pollution level can be seen in fig 1(c).

III. SWOT ANALYSIS OF CURRENT TECHNOLOGY

This section presents the SWOT analysis of the current technological infrastructure used by Himachal Pradesh State Pollution Board (HPSPB), to measure the air pollution. Presently. HPSPB measures only two locations in the city of Shimla, for which the data of last six years has already been presented above. The SWOT analysis of the present technology in use is as given below:

Strengths:

- Easy to operate
- No need of specialized or technical manpower
- The working of the instruments not sensitive to weather conditions
- Ruggedness level is high
- No interference from external electromagnetic signals
- No special band requirement for communications
- No security threat to the data
- Readily available technology
- Stable technology

Weakness:

- Measurement of only two components of air pollution
- Manual data collections
- Manual data processing
- Limited location coverage (only two locations of Shimla have been covered)
- Higher cost
- Non- availability of real time data to concerned officials
- Non- availability of real time data and its analysis, precaution to the end users.
- Higher power consumption
- Non-availability of alarming solutions
- Low frequency of data gathering

Opportunity:

- Automation in data collection and processing
- Data analysis can be made available to the end users with it precautionary features.
- Alarming systems can be attached with the air pollution data, which can be useful in industrial areas to take the corrective measures to control pollution by concerned authorities.
- A low power consumption solution
- To design a low cost solution
- Solution providing maximum coverage area
- ICT – enabled solution
- Measurements of all the components/ ingredients of air pollution

Threats:

- A low frequency data might lead to wrong results and conclusions
- Limited area coverage of measurements may give us an incorrect picture of air pollution level.
- Non- measurements of components other than SO_2 and NO_2 might lead to a harmful situation to the habitants of the area.
- Non availability of real time data with its analysis with precautionary features will lead to unawareness towards the pollution which in turn will contribute to increasing the pollution level.

IV. WSN FOR AIR POLLUTION MONITORING

In view of the above opportunities, this section presents the solution for the various issues related to the current technologies used in monitoring air pollution established by HPSPCB, with the use of Wireless Sensor Network (WSN) with the off the shelf components and their integration with the existing Himachal Pradesh State Wide Area Network (HIMSWAN).

A. Wireless Sensor Network:

Wireless Sensor Network (WSN) is an automated network of interconnected sensor located in wide spread area, used to measure almost all the physical parameters such as temperature, pressure, humidity, pollutants, vibrations,

electromagnetic fields and signal, and to transfer the gathered data to a centralized location for processing. Current generations of sensor devices are very small, rugged, low cost and very well calibrated. The main characteristics of a WSN are given below [7]:

- Low power consumption constraints for nodes, using batteries or solar energy harvesting
- Ability to cope with node failures
- Mobility of nodes
- Dynamic network topology
- Lesser Communication failures
- Heterogeneity of nodes
- Scalability, large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Unattended operation
- Highly sensitive

.

B. HIMSWAN

HIMSWAN is, Himachal State Wide Area Network providing minimum of 2 Mbps connectivity up to the block level through the Public Private Partnership (PPP) model. This bandwidth may increase in phases to 16 mbps from one district to another and from district headquarters to the State capital [8]. The Project is aimed at providing Government Offices and Integrated Community Service Centers at State, District, Sub-Divisional, Tehsil and Block headquarters in Himachal Pradesh to connect to the state capital of Himachal Pradesh. The network architecture of HIMSWAN is presented in Fig. 2

Figure 2. HIMSWAN Network Architecture

C. Proposed Solution: Integration of WSN with the existing WAN

We propose to build a ubiquitous wireless sensor network for air pollution monitoring by adding a layer of the off the self available WSN component and WSN data processing and interpretation layer in HIMSWAN network of the Himachal Pradesh. Network connectivity architecture is given in Fig.3. This solution is expected to provide a complete answer for all the limitations and challenges involved in implementing a WSN based features, as discussed below:

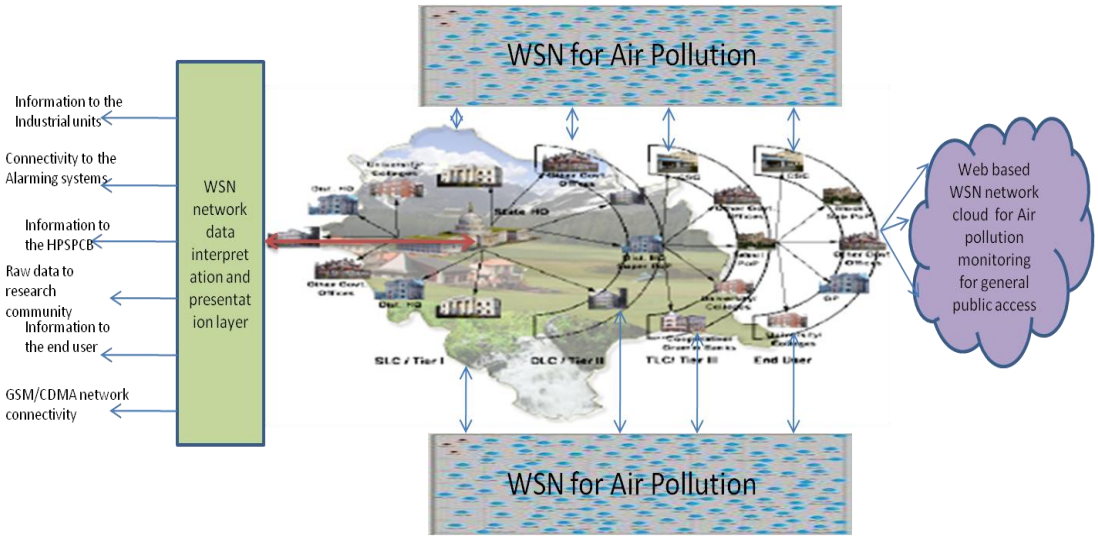


Figure 3 WSN Connectivity Archite4cture

Various characteristics of proposed Ubiquitous Wireless Sensor Network and their possible solutions are as follows:

- **Coverage:** The sensor network is connected with HIMSWAN, which is having a very wide coverage in the state of Himachal Pradesh.
- **Power Consumption:** WSN off the self component is expected to be installed in location covered by HIMSWAN only, therefore no need of power backup.
- **Connectivity and Performance:** HIMSWAN is a wired solution based on fiber connectivity, therefore WSN application data will be error free where higher level of performance can be expected.
- **Automatic Processing:** No manual collection of the air pollution data is required. Data will be automatically transferred to the central processing station.
- **Automatic Analysis and Reporting:** An automatic analysis system can analyze the available data and generate the results and reports within no time.
- **Awareness creation through CDMA/GSM based network**: The WSN air pollution results can be sent to the end users with the help of GSM/ CDMA based network. This will enhance the awareness level among the society and will definitely contribute in lowering the pollution level.
- **Security:** This architecture is very secure both at the physical and dynamic level.
- **Man power Requirement:** No need for extra manpower to maintain the network as HIMSWAN manpower will be able to manage this network without any extra burden.
- **Real Time Data availability:** Air pollution data will be available on line to various concerned end users and research organizations.
- **Total component measurement:** The off self components available are able to measure all the pollutants of the air.
- **Alarming System:** Alarming system can be attached to this WSN network.
- **Low Cost:** This solution will be with a low cost technology, as we are able to use the existing ICT infrastructure of the state and WSN off the self component itself are very much cost effective.

The successful implementation of this solution will help in providing real time data of wide spread covered area to the centralized location and will help better monitoring of air pollution.

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