Testbed Implementation of a Pollution Monitoring System Using Wireless Sensor Network for the Protection of Public Spaces

Siuli Roy, Indian Institute of Management Calcutta, India
Anurag D, Indian Institute of Management Calcutta, India
Somprakash Bandyopadhyay, Indian Institute of Management Calcutta, India

ABSTRACT

Air pollution is an important environmental issue that has a direct effect on human health and ecological balance. Factories, power plants, vehicles, windblown dust and wildfires are some of the contributors to pollution. Reasonable simulation tools exist for evaluating large scale sensor networks, however, they fail to capture significant details of node operation or practical aspects of wireless communication. Real life testbeds, capture the realism and bring out important aspects for further research. In this paper, we present an implementation of a wireless sensor network testbed for automatic and real-time monitoring of environmental pollution for the protection of public spaces. The paper describes the physical setup, the sensor node hardware and software architecture for “anytime, anywhere” monitoring and management of pollution data through a single, Web-based graphical user interface. The paper presents practical issues in the integration of sensors, actual power consumption rates and develops a practical hierarchical routing methodology.

Keywords: Hierarchical Routing, Pollution Sensors, Real-Time Monitoring, Testbed Implementation, Zigbee

INTRODUCTION

The availability of consistent, accurate and timely information on environmental conditions greatly improves the speed of planning and decision making (Hammons & Chisholm, 2006). Such information, although required for most businesses, is of particular importance in chemical factories, mines and other high investment industries. The availability of precise
information enables businesses to respond in quick time and take preventive measures against emission of poisonous gases and other hazards, thus improving the safety of personnel and equipment.

Air pollution (Jung, Lee, Lee, Ryu, & Nittel, 2008; Ma, Richards, Ghanem, Guo, & Hassard, 2008) is an important environmental issue that has a direct effect on human health and ecological balance. The primary airborne pollutants covered by European legislations are: SO₂, NOₓ (NO/NO₂), Benzene, Ozone, CO/CO₂ and particulate matter (PM10/PM2.5). Air pollution has diverse causes and sources. “Stationary sources” such as factories, power plants and smelters; “mobile sources” such as automobiles; and “natural sources” such as windblown dust and wildfires are primary contributors to air pollution. Due to the trans-boundary nature of airborne pollutants, it is difficult for any single organization to take responsibility for overall emission levels. Thus, the control of air pollution is entirely legislation driven. As such the passing of new legislation may only be effective if the pollution level in the specified compounds can be monitored accurately using sensors.

Environmentalists can use sensors to measure atmospheric pollution and monitor industrial emissions; safety monitors can use sensors to detect harmful chemical vapours and explosives in public spaces, government or military facilities and chemical processing plants.

Gas sensor technologies are still developing and have yet to reach their full potential in capabilities and usage (Jung et al., 2008). Some technologies are particularly accurate but prohibitively expensive for large-scale deployment. By using a sensor network, the problem of false positives could potentially be reduced. Multiple outputs can be compared for a more accurate analysis.

However, realizing sensor-based networks using wires are not feasible solutions for large scale deployment. Wireless sensor networks (Akyildiz & Wang, 2005) offer powerful new ways to monitor air quality and without the costs of major new installations or wire-runs that are typically associated with these types of projects. Wireless sensor networks comprises of:

- A multitude of bi-directional radio transceivers with sensors known as sensor nodes or tags. The sensors include a wide variety of pollution detectors and are connected together using the communicational capability of the wireless nodes to form the core of our proposed pollution monitoring system. Sensors capture pollution data and communicate them wirelessly over the network to a remote control station for further analysis and generation of alerts during critical events.

- The wireless sensor nodes are arranged in a networking topology called a “mesh.” Mesh networking is a type of network where each node can communicate with multiple other nodes thus enabling better overall connectivity than in the traditional hub-and-spoke or star topologies. State of the art mesh networks often have some or all of the following characteristics:
  - They are self-forming. As nodes are powered on, they automatically enter the network, compute
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