Chapter 4.8
Testbed Implementation of a Pollution Monitoring System Using Wireless Sensor Network for the Protection of Public Spaces

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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: \( \text{SO}_2 \), \( \text{NO}_x \) (\( \text{NO} / \text{NO}_2 \)), Benzene, Ozone, \( \text{CO/CO}_2 \) 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 efficient routes for data forwarding through their neighbors and are ready for operation.
  - They are self-healing. As a node leaves the network, the remaining nodes automatically re-route their packets around the out-of-network node to ensure a more reliable communication path.
  - They support multi-hop routing. This means that data from a node can jump through multiple nodes before delivering its information to a host gateway or controller that may be monitoring the network thus extending the reach and range.

The self-forming and self healing coupled with battery operable attributes of a mesh sensor network make it ideal for environmental monitoring applications in a wide range of facilities.

This article presents a generic framework for “anytime anywhere” visibility of sensor data from a remote wireless sensor network using the Internet (Pujolle, 2006). Active RFID tags, combined with sensors and actuators, form the proposed wireless sensor network based on IEEE 802.15.4 (IEEE, 2003). The architecture also enables the control of the environment by triggering actuators. Lastly, we elaborate a test-bed implementation for monitoring...
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