An indoor environment monitoring system using low-cost sensor network

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Abstract

Energy consumption in buildings account for a significant proportion of total energy consumed worldwide. Since humans spend about 90\% of their time in buildings, it is essential that the indoor environment quality is improved and energy consumption is minimised. This paper presents the development and implementation of a low-cost sensor network system that can be used to monitor important indoor parameters to achieve high indoor environment quality. The prototype system shown in this paper has been tested in an office building and improvements made. The system, with further improvements can be used to control HVACs, and indoor environment conditions automatically and has great potentials for energy saving.

Keywords: indoor environment, low-cost, sensor network, wireless sensor network, environment monitoring

1. Introduction

A good indoor environment is associated with high indoor air quality and thermal comfort. The indoor air quality and thermal comfort subsequently are significantly affected by the temperature, relative humidity, airflow pattern and other parameters in the indoor space [1, 2]. In order to provide a quality indoor environment, the use of heating, ventilation and air-conditioning (HVAC) systems have been on a rapid increase in recent years, especially in developed and developing countries, along with both complex and sophisticated control systems [3, 4]. Although
the control systems are meant to provide the required comfort while minimising energy consumption, many of these control systems have failed to satisfy the occupants’ comfort need and/or reduce energy consumption [5].

This is as a result of the model being used to represent the rooms in the buildings being too simplistic with assumption of perfectly mixed (homogenous distribution) conditions [6]. In practice, in indoor environments, a temperature sensor is normally placed on the wall adjacent to doors or heating/cooling equipment and assumes that the measured parameter is representative of the whole room and is sufficient to achieve good thermal comfort. Such global sensing design would not perform well for optimal monitoring and feedback to dynamic building system operation or achieve optimal efficiency, as the measured parameter exhibit local indoor variation (e.g. indoor temperature variation) [7].

Placement of more sensors or a sensor network in the room is proposed to solve the above problem and provide more detailed monitoring or measurements. As such, better control of relevant parameters and system disturbance at multiple positions in the room can be achieved. However, professional sensors are expensive and the cost might prohibit such application, hence the need for low-cost sensor network.

Several studies have been carried out involving use of sensor networks in large scale/ citywide environment, indoor air quality/pollution, habitat, traffic monitoring with focus on various aspects like software, hardware, and middleware, and on sensor nodes, as well as on energy consumption of the sensor network [8-11]. However, focus on using multiple sensors to achieve better monitoring performance is still limited. In this paper, we present the development of a low cost sensor network comprising of sensors that can be placed in multiple locations in the room to help monitor parameters that can help achieve optimized control of HVAC system in the room.

2. Development of the low-cost sensor network

2.1. Design overview of the monitoring system

The developed low-cost indoor monitoring system employs an overall system architecture shown in fig 1. The main components include the temperature sensor nodes (digital and analogue), humidity sensor node, XBee wireless transceiver and SD shield. These nodes are all managed by Arduino microcontroller using ZigBee data protocol [8]. The recorded data is transmitted to PC for viewing. Detailed description of the components is provided in the following sub-sections.

![](image)

Fig. 1. Flowchart of the monitoring system.

2.2. Hardware

This subsection briefly describes each hardware component used in the monitoring system development. Table 1 provides a quick view of the entire components as can also be seen in fig 2. The equipment specifications as well as the associated costs are also shown on table 1.

- Temperature sensors

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>DS18B20</td>
<td>Temperature sensor</td>
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