# Chapter 12
# A WSN-Based Building Management Framework to Support Energy-Saving Applications in Buildings

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## ABSTRACT

*Using wireless sensor networks (WSNs) for auditing and managing the energy consumption in a building is an emerging research area that includes a number of novel applications such as activity pattern recognition, adaptive load shifting, and building energy profiling in domestic and industrial settings. This chapter defines the specific requirements for applications of energy management in the building context and proposes a novel framework for building management (BMF) to support heterogeneous platforms. To allow flexible node activity grouping, BMF defines roles and operations derived from the mathematical set theory, while it optimizes transmissions through a mechanism of adaptive packet size. BMF has been implemented and tested in TinyOS. Results show an increase in reliability with respect to existing transmission schemes that can be traded off to reduce energy consumption.*

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## INTRODUCTION

The worldwide call for energy reduction, demonstrated by various international policies, is accelerating the introduction of energy saving techniques. It is recognized that buildings consumption accounts for more than 40% of worldwide energy use and has faster grown rate than transportation and industry energy consumption. Reducing energy consumption of buildings requires generating energy awareness among residents and controlling devices within the building. Strong evidences suggest that occupants can actively adapt their behaviour to energy saving with suitable feedback, support, and incentives, reducing significantly and cost-effectively energy use without impacting adversely their comfort (Stern, 1999).

To achieve this goal, the use of wireless sensor networks to audit buildings and control equipment represents a viable and more flexible solution to traditional building monitoring and actuating systems (BMAS), which require retrofitting the whole building and therefore are difficult to implement in existing structures. In contrast, solutions based on WSN (Akyildiz et al., 2002; Akyildiz & Vuran, 2010) for monitoring buildings and controlling equipment, such as electrical devices, heating, ventilation and cooling (HVAC), can be installed in existing structures with minimal effort. This should enable monitoring of space usage and energy (electricity, gas, water) while facilitating the design of techniques for intelligent device actuation. In order to achieve this, WSN-based building auditing necessitates devising a dedicated management framework for (1) the management of a range of cooperating networked entities, (2) the profiling of the energy spent and (3) the development of applications for controlling the energy consumption in buildings.

This paper proposes a Building Management Framework (BMF), which is a domain-specific framework for energy saving techniques in buildings. The contribution of the framework is twofold: from one side the BMF assists the application developer with an extensible Application Programming Interface (API) to allow profiling the energy of the building and subsequently control the existing HVAC and electrical equipment. From the other side, the BMF is a network practitioner in the sense that facilitates the deployment of heterogeneous nodes, management and maintenance of the network operation. This is achieved by providing a set of embedded functionalities and a corresponding middleware at the base station (BS) side. Moreover, we demonstrate some advantages resulting from a reduction of the bytes sent over the air, during configuration phase achieved through an optimization of the configuration packets. BMF is currently implemented in TinyOS (Levis, 2006) and supports the interoperation of TelosB (Polastre, Szewczyk, & Culler, 2005), Tyndall (Barton et al., 2006), Epic (Jiang et al., 2009), and KMote (Madabhushi, 2007) platforms with heterogeneous sensing capabilities.

The chapter is organized as follows: we first introduce the main requirements for a building energy auditing system for office buildings highlighting the unsuitability of some existing frameworks when used in the context of building monitoring. Then we introduce BMF and describe its main components and processing levels. Following, the chapter provides some initial performance analysis before some future works and the conclusions.

## BUILDING MANAGEMENT: REQUIREMENTS AND OBJECTIVES

Many new structures incorporate energy management systems such as intelligent lighting, HVAC control systems that allow profiling the energy spent in the building. However, a much larger portion of existing buildings do not have any energy monitoring retrofitted. WSNs represent an appropriate solution to allow energy monitoring in such buildings. For example this would allow quantifying and understanding how the energy