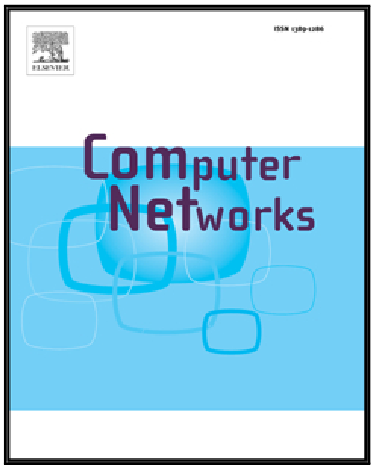

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Energy-Efficient Coverage Protocol Based on Stable and Predictive Scheduling In Wireless Sensor Networks.

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Abstract

One important issue in wireless sensor networks is the area coverage problem. It describes how well a sensing field is supervised by sensors. In fact, an appropriate coverage strategy needs simultaneous activation of a large number of nodes as each location should be covered by at least k sensors, with $k > 1$ for many applications. Some sensors may be redundant because of overlaps in the nodes' regions. Therefore, scheduling techniques alternate the redundant sensors' activity to reduce uniformly their energy consumption. However, frequent alternation between states and repetitive eligibility executions during the scheduling process itself, lead to significant energy waste. In this paper, we propose the Stable and Predictive Energy-aware Coverage Scheduling (SPEC) protocol. It does not only reduce the scheduling energy waste but it extends the coverage lifetime as well. Indeed, SPEC removes useless transitions from the scheduling strategy and prevents the run of unnecessary eligibility executions. Simulation results confirm that SPEC outperforms existing well-known periodic scheduling protocols, in terms of energy preservation, network lifetime and coverage preservation.

Keywords: Coverage, Scheduling, Stability, Prediction, Redundancy.

1. Introduction

A wireless sensor network (WSN) is composed of small affordable sensors designed to collect, process and transmit (to a sink node) sensed information. Each sensor node is a small device that includes three basic units: a sensing unit for data acquisition, a processing unit for local data processing and storage, and a wireless communication unit for data transmission to a sink node. One of the critical challenges in WSNs is energy conservation. Indeed, sensor nodes are tiny devices with limited energy and are usually deployed in hostile environments. Thus, recharging or replacing their batteries may be impossible.

Coverage, which reflects how well a sensor field is monitored, is one of the most important performance metrics to measure in WSNs. It quantifies how well sensors can sense events at some locations [1]. The coverage approach can be centralized or distributed [2]. In the centralized approach [3–5], the coverage algorithm runs at a special station (usually a sink node) where energy, communication and computation constraints can be ignored. Centralized approaches require global information on the whole network, run slowly and have low adaptability to network changes. Conversely, with distributed ones [6–9], the decision process is locally and simultaneously carried out at each sensor node, which needs only local information, thus being more adaptable to the scalable and dynamic nature of the network. In most distributed approaches, a coverage degree (k) should be preserved in order to guarantee that events can be captured by different nodes. By definition, a field has a coverage degree of k, if it is covered by at least k sensors. So, the higher the coverage degree is, the better will the monitoring of the field be [9–11]. However, this requires the simultaneous activation of a large amount of nodes, some of which may be redundant; they may collect and forward the same information causing redundant communication overhead and thereby leading to energy waste.

To preserve energy and extend the network lifetime while achieving coverage, most energy-efficient coverage solutions first detect redundant sensors through *eligibility algorithms* also known as *coverage redundancy algorithms (CRAs)*, then schedule their activity through *scheduling techniques*. Note that most existing scheduling techniques adopt a periodic approach; that is, they alternate the redundant nodes' activity to smoothly reduce their energy consumption.

However, the frequent and dynamic alternation between active and sleep modes [6, 12–16] leads to two major shortcomings:

1. An extra energy consumption may be incurred due to repeated transitions, as the switch energy is not always negligible.
2. Further computation and communication costs may

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