Formal Probabilistic Analysis of Lifetime for a WSN for Border Monitoring

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Abstract. Scheduling sensor nodes in Wireless Sensor Networks (WSN) for lifetime management purposes is a simple and intuitive approach. However, it is also crucial to not compromise on the main performance requirements of the considered application. For mission-critical WSN applications, different Quality of Service (QoS) requirements on network performance have to be satisfied. Nevertheless, traditional techniques usually focus on the average performance values without considering the targeted QoS requirements. In this paper, we provide rigorous formalizations in higher-order logic of the network lifetime maximization problem, under QoS constraints, for randomly-scheduled wireless sensor networks. We also use natural deduction based reasoning to verify the desired properties using theorem proving. In particular, we build upon our earlier developments on coverage and detection analysis to formally analyze the lifetime maximization problem for a border monitoring application.

Keywords: Wireless sensor networks, Performance analysis, Theorem proving, Nodes Scheduling, Network lifetime, Border monitoring

1 Introduction

Wireless Sensor Networks (WSNs) have emerged as a key enabler technology for various surveillance applications [41] including environmental monitoring and object tracking. Since sensors are basically battery-powered, energy saving arises as the most critical requirements. In a WSN for forest fire detection, where sensors are randomly and densely deployed, the network should be able to ensure the monitoring of the area while being functional for a long period. As a wild fire occurs occasionally, some sensors can be intuitively deactivated by partitions to save the whole network energy, and thus extend the network lifetime [35]. In this context, the k-set randomized scheduling [21] is an efficient scheduling approach, which mainly consists in randomly organizing the set of nodes into k subsets.