Chapter 13
Scheduling Algorithm for Wireless Sensor Networks

ABSTRACT

In Wireless Sensor Networks (WSNs), scheduling of the sensors is considered to be the most effective energy conservation mechanism. The random and unpredictable deployment of sensors in many WSNs in open fields makes the sensor-scheduling problem very challenging and thus randomized scheduling algorithms are used. The performance of these algorithms is usually analyzed using simulation techniques, which do not offer 100% accurate results. Moreover, probabilistic model checking, when used, does not include a strong support to reason accurately about statistical quantities like expectation and variance. In this chapter, the authors overcome these limitations by using higher-order-logic theorem proving to formally analyze the coverage-based random scheduling algorithm for WSNs. Using the probability theory formalization, described in Chapter 5, the authors formally reason about the probability of some events that are interesting in the context of WSN coverage.
13.1 COVERAGE-BASED RANDOMIZED SCHEDULING ALGORITHM

Wireless sensor networks (WSNs) have been proposed as an efficient solution to monitor a field without any continuous human surveillance. Such networks are composed of small tiny devices wirelessly connected over the field. The main task of sensors involves taking measurements of the monitored event. According to these measurements, a decision procedure is made at the base station. The WSNs are extensively being deployed these days in a variety of applications like detection of natural disasters or biological attacks and military tracking.

Minimizing energy requirements for the sensor nodes is very critical given the fact that these nodes are always stand-alone and battery powered. Scheduling of the nodes is one of the most widespread solutions to preserve energy (Lin & Chen, 2008; Jain & Srivastava, 2007; Liu, Wu, Xiao & Sun, 2006). It consists in splitting the network on several sub-networks, which work alternatively. The biggest challenge involved in this approach is the ability to provide continuous coverage, i.e., reliable monitoring or tracking by sensors.

Consider a WSN that deploys $n$ sensors over a field of size $a$. All sensors have the same task; gathering data and routing it back to the base station. The deployment of nodes over the two-dimensional field is random and thus no location information is available. The size of the sensing area of each sensor is denoted by $r$. A sensor can only sense the environment and detect events within its sensing range. A point of the monitored field is considered to be covered when any event occurring at this point can be detected by at least one active sensor (Xiao et al, 2010). The probability $q$ that each sensor covers a given point is $r/a$. The random scheduling of the nodes assigns each sensor to one of the $k$ sub-networks with equal probability $1/k$. During a time slot $T_i$, only the nodes belonging to the sub-network $i$ will be active and can cover an occurring event. Hence, the disjoint sub-networks created will work alternatively. Let: $S_i$ be the set of sensors that belongs to the sub-network $i$ and covers a specific point inside the field, $S$ be the set of nodes covering a specific point inside the field, and, $c$, the cardinality of $S$.

For illustration purposes, consider randomly deployed eight nodes in the monitored region. The nodes are identified by IDs ranging from 0 to 7. There are two sub-networks called $S0$ and $S1$. Each node chooses at random between 0 and 1 in order to be assigned to one of these two sub-networks. Suppose that nodes 0; 2; 5; 6 select the number 0 and join the subset $S0$ and nodes 1; 3; 4; 7 choose the number 1 and join the subset $S1$. Thus, the two sub-networks will work alternatively. In other words, when the nodes 0; 2; 5; 6, are active, the nodes 1; 3; 4; 7 will be idle and vice versa.
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