SAT Representation of Randomly Deployed Wireless Sensor Networks*

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Abstract

In this article we introduce two models for randomly deployed wireless sensor networks (WSN). A WSN consists of many sensors which can communicate with other nearby sensors by broadcasting messages. In our case the sensors are deployed randomly, i.e., some of them might be very near to each other, others might be far from the rest of the sensors. It is an interesting question whether the randomly deployed WSN has some important feature, like all-all communication is possible, or not. We can answer these questions by modeling the network and generating a SAT problem out of it. Modern SAT solvers can handle very large SAT problems even with thousands of variables, so we can verify even very large WSNs.

In our first model sensors can communicate with other sensors in their transmission range. We model the communication by logical implication. If sensor A can send message to sensor B and C, then the model is: $((A \Rightarrow B) \wedge (A \Rightarrow C))$. In this model we can ask whether a sensor can send message to another one through some other sensors. More specifically we can ask whether all sensors can send message to all other ones, i.e., all-all communication is possible or not. We show how to translate this model and these questions into a SAT problem. If the SAT problem is unsatisfiable, then the answer is true for the question, otherwise false.

In our second model each sensor belongs to one or more subclusters. A subcluster consists of one or more sensors which are near enough to each other that all of them can communicate with all other ones. In the subcluster there is no cluster-head as it is usual in other models, so there is peer-to-peer communication in the subclusters. In this model a sensor can sleep to save energy, so a sensor is either sleeping or awake. We model each sensor by a Boolean variable which is true if the sensor is awake otherwise false. In the model we can state that at least one or more sensors must be awake in any time. Two

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subclusters can communicate if they have a common sensor which is awake. If a subcluster consists of sensors A, B, and C, and at least two of them must be awake in any time, then the model is: $((A \wedge B) \vee (A \wedge C) \vee (B \wedge C))$. Then we can ask whether two subclusters can communicate independently how many sensors are sleeping, or more specifically, any subcluster can communicate with any other ones? We show how to translate this model and these questions into a SAT problem. If the SAT problem is unsatisfiable, then the answer is true for the question, otherwise false.

We also show how to combine these models.

Keywords: WSN, RFID, Logic model, SAT representation

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