TRANSMISSION SCHEDULING IN WIRELESS SENSOR NETWORKS WITH COOPERATIVE COMMUNICATIONS

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ABSTRACT

Energy harvesting and cooperative communication using relays are two promising technologies to overcome the power limitations of Wireless Sensor Networks (WSNs) with battery-powered nodes. In order to maximize the benefits of these technologies and ensure that the largest possible fraction of events are successfully reported, efficient algorithms need to be designed to address the problem of transmission scheduling in the network. In particular, relay usage scheduling is critical towards addressing the trade-off between energy consumption and efficiency in the network and in this thesis we address this issue. We first consider the problem of scheduling transmissions in a sensor network with cooperative communications and energy harvesting. We first model the system using a stochastic framework and formulate the scheduling problem at a source sensor node using a Markov Decision Process (MDP) framework and an upper bound on the performance of arbitrary policies is determined. In the MDP framework, every node in the network has full state information about its neighbors, which is not practical. Following that, the scenario when only partial state information about the energy harvesting and traffic generation processes of the relay is available at the source is considered and formulated as a Partially Observable Markov Decision Process (POMDP). We show that the POMDP can be transformed into an equivalent, completely observable Markov decision process. We further characterize an approximate solution to the optimality equations, which provides us with useful insights into the system dynamics. We observe that the structure of optimal policy is quite sensitive to system parameters, which makes it unsuitable for practical deployment. Therefore, we design a simple and practical threshold based relay scheduling policy, and show using simulations that it achieves close to the optimal performance. Next, we address the question of throughput guarantees through distributed scheduling in wireless sensor networks with relay based cooperative communications. We prove that in a single frequency network with bidirectional, equal power communication, low complexity distributed maximal scheduling attains a guaranteed fraction of the maximum throughput region in arbitrary wireless networks. We also show that the guarantees are tight in the sense that they cannot be improved any further with maximal scheduling. Finally, we investigate the performance of maximum schedulers for these networks by extending the existing work on maximum schedulers for wireless networks without cooperative relays.