ENERGY EFFICIENT MAC PROTOCOLS IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Wireless sensor networks (WSNs) use battery-operated computing and sensing devices. The battery power is limited and is difficult to replace and replenish. Thus, the energy efficiency of WSNs is of critical importance. These characteristics of sensor networks and their applications motivate the deployment of energy efficient protocols at all layers. In this thesis, our focus is on energy efficient Medium Access Control (MAC) protocols and we explore different power saving mechanisms in this context.

In the first part of the thesis, we develop analytic models to evaluate the performance of two polling based MAC protocols in terms of their delay, energy consumption and optimal cluster head selection. We show that these two polling based MAC protocols outperform the decentralized MAC protocols in both metrics.

Next, we propose MAC protocols which use cooperative Multi-Input and Multi-Output (MIMO) techniques and analyze their performance. Cooperative MIMO is a power saving mechanism that can achieve the same level of successful packet transmission rate while consuming less energy. In time critical applications, power saving mechanisms using sleep and wake cycles are not appropriate, due to the longer packets delays when packets arrive during the sleep period, and cooperative MIMO techniques are attractive alternatives. In this thesis, we propose three distributed cooperative MIMO MAC protocols and develop analytic models to evaluate their performance in terms of the delay, energy consumption, and transmission error rate. We show that the proposed MAC protocols can outperform point to point MAC protocols.

To complete the thesis, we develop MAC protocols and an architecture for underwater sensor networks. Due to the inherently different characteristics of water as a medium for signal propagation, underwater acoustic sensor networks face unique challenges in the design and development of communication and networking protocols. We present an architecture for data transfer in underwater networks that primarily gather non delay-sensitive data. The proposed system is based on the

usage of a mobile sink that traverses the network to transfer data from the sensor nodes directly and avoid multi-hop transmissions. Area partitioning algorithms are proposed that divide the network into regions so that tradeoff may be achieved between minimizing the distance traveled by the sink and the formation of clusters that maximize the throughput. To reduce the transfer time of control messages to the sensors, a transmission mechanism based on superposition coding is developed. Finally, a MAC protocol is developed to facilitate the transmissions. We show that our proposed architecture can achieve higher data transmission rates and less energy consumption.

In this thesis, sleep and wake cycles, cooperative MIMO technique and energy efficient communications architecture have been discussed in WSNs and UW-ASNs. By using these proposed polling based MAC protocols, cooperative MIMO MAC protocols and mobile sink architecture with superposition coding, the networks achieve long lifetime and high performance.