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Title of the Thesis : Some Investigation into Energy Constraints in Wireless Sensor Networks

Abstract

As a matter of fact, modern wireless sensor networks consist of a large number of inexpensive devices that may be networked via some specific low power wireless communications. In the view of the significant advances made during the past decade in the field of microelectronics, sensing, analog and digital signal processing, wireless communications, and networking, wireless sensor network technology is going to have a significant impact on our lives in the twenty-first century. Proposed applications of sensor networks include environmental monitoring, natural disaster prediction and relief, intruder detection in military surveillance, healthcare, monitoring and control of industrial equipment, traffic control and home automation.

The present thesis focuses on theoretical as well as practical aspects of wireless sensor networks, aiming to provide signal processing and communication perspectives on the design of large-scale networks. In the thesis, we have elaborated some specific energy-efficient communication techniques that take consideration of these properties into account in the design of physical-layer communication. A significant reduction in the impact of flat fading, diversity combining may lead to significant power savings. Further, MIMO systems can significantly increase the channel capacity and reduce the transmission energy in wireless fading channels. Sensor nodes using MIMO techniques would require lower transmission power to achieve the same bit error rate (BER) as compared to point to point communications. In addition applying multiple antenna techniques directly to sensor network is very much impractical since the restricted size of a sensor node usually supports a single antenna. Further, we may use cooperative transmission and reception from antennas in a group of sensor nodes to construct a system fundamentally equivalent to a MIMO system for wireless sensor networks (WSNs). The MIMO transmission system achieves lower overall energy consumption as compared to the point to point communication technique.

The efficiency of resources utilization can be further improved if we design a network to optimize application-dependent performance measures. Particularly, data aggregation has been proposed to mitigate traffic in multi-hop sensor networks. We focus on data-aggregation techniques in energy-constrained sensor networks. The main purpose of data-aggregation algorithms is to gather and aggregate data in an energy efficient approach so that network lifetime may be improved. In this regard, we have proposed an energy model for wireless sensor networks based on cooperative multiple-input multiple-output (MIMO) based communication while considering both the transmission energy and data aggregation energy.

Findings

The thesis presents some investigations into energy constraints in wireless sensor networks. This thesis has been organized into eight chapters. The first chapter is devoted to the introduction of the research work carried out in the thesis. The brief description of wireless sensor networks and

development of sensor network technology along with application of wireless sensor networks is described. A concise review of technical challenges for implementing efficient sensor networks is presented. The objective of chapter-2 is to provide an overview of wireless sensor networks and main approaches to energy saving methods in Wireless Sensor Network. The chapter summarizes the relevant aspects of research and development of various energy saving techniques. These energy saving techniques are basically used to enhance the life time of sensor nodes in wireless sensor networks. We then consider a point-to-pint link in chapter 3, where, we minimize the total energy consumption for transmitting a given number of bits by considering both the transmission energy and the circuit processing energy. For both MQAM and MFSK, we curtail the total energy consumption required to meet a given BER requirement by optimizing the transmission time. In chapter 4, we show that cooperative MIMO systems can be constructed by means of node cooperation on both the transmitting side and the receiving side, even though each sensor node is too small to mount multiple antennas. By transmitting and/or receiving information jointly, we illustrate that remarkable energy savings is possible for transmission distances larger than a given threshold, even when we take into consideration the local energy cost necessary for joint information transmission and reception. We also illustrate that over some distance ranges; cooperative MIMO transmission and reception can simultaneously achieve both energy savings as well as delay reduction.

In chapter 5, we have described the virtual MIMO arrangement for wireless sensor networks which can save total energy when it is compared with typical SISO system. It has been justified that projected system is more energy efficient as compare to the reference SISO for long haul communication. Simulations show that with proper design, cooperative MIMO based routing algorithm is more energy efficient as compared to single input single output (SISO) for larger distances and extend sensor network lifetime. In chapter 6, we have proposed STBC based communication architecture for energy-limited wireless sensor networks based on V-BLAST receiver processing. The simulation results show that the projected V-BLAST processing based virtual MIMO design can offer significant energy savings over conventional SISO communication based wireless sensor networks. It also shows that in general larger virtual MIMO schemes will result in greater energy efficiency with fixed rate systems. In chapter 7, we have integrated the energy model for data aggregation into cooperative multiple-input single-output (MISO) and multiple-input multiple-output (MIMO) schemes to further optimize the total energy consumption in wireless sensor networks. Simulation results illustrate that the proposed cooperative multi-input multi-output (MIMO) with data aggregation based communication method can offer substantial energy savings in wireless sensors network provided that the system is designed thoughtfully for e.g. vigilant concern of broadcast distance requirements, rate optimization as well as latency constraints.

In chapter 8, the summery of the thesis has been discussed in details. A comprehensive evaluation of the thesis work is carried out. Future work of research work has also been presented in the chapter. As a whole, It is concluded that, in wireless sensor networks, cooperative MIMO and data aggregation can be used together to increase the life time of sensor node.