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From September 2004 to October 2006 she joined SIC (Instrumentation and Communications Systems) group of Electronics Department of UB as research assistant. She participated in TRANSAMI (Transceivers for applications in an Ambient Intelligence Environment) project between SIC and EPSON Europe Electronics related to the design of an IEEE 802.15.4 compliant sensor mote. Moreover, between September 2005 and September 2006 she was teaching assistant.

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Abstract

In Wireless Sensor Networks (WSN), the ability of sensor nodes to know its position is an enabler for a wide variety of applications for monitoring, control, and automation. Often, sensor data is meaningful only if its position can be determined. Many WSN are deployed indoors or in areas where Global Navigation Satellite System (GNSS) signal coverage is not available, and thus GNSS positioning cannot be guaranteed. In these scenarios, WSN may be relied upon to achieve a satisfactory degree of positioning accuracy.

Typically, batteries power sensor nodes in WSN. These batteries are costly to replace. Therefore, power consumption is an important aspect, being performance and lifetime of WSN strongly relying on the ability to reduce it. It is crucial to design effective strategies to maximize battery lifetime. Optimization of power consumption can be made at different layers. For example, at the physical layer, power control and resource optimization may play an important role, as well as at higher layers through network topology and Medium Access Control (MAC) protocols.

The objective of this Thesis is to study the optimization of resources in WSN that are employed for positioning purposes, with the ultimate goal being the minimization of power consumption. We focus on anchor-based positioning, where a subset of the WSN nodes know their location (anchors) and send ranging signals to nodes with unknown position (targets) to assist them in estimating it through distance-related measurements. Two well known of such measurements are received signal strength (RSS) and time of arrival (TOA), in which this Thesis focuses. In order to minimize power consumption while providing a certain quality of positioning service, in this dissertation we research on the problems of power control and node selection. Aiming at a distributed implementation of the proposed techniques, we resort to the tools of non-cooperative game theory.

First, transmit power allocation is addressed for RSS based ranging. Using game theory formulation, we develop a potential game leading to an iterated best response algorithm with sure convergence. As a performance metric, we introduce the geometric dilution of precision (GDOP), which is shown to help achieving a suitable geometry of the selected anchor nodes. The proposed scheme and relative distributed algorithms provide good equilibrium performance in both static and dynamic scenarios. Moreover, we present a distributed, low complexity implementation and analyze it in terms of computational complexity. Results show that performance close to that of exhaustive search is possible.

We then address the transmit power allocation problem for TOA based ranging, also resorting to a game theoretic formulation. In this setup, and also considering GDOP as performance metric, a supermodular game formulation is proposed, along with a distributed algorithm with guaranteed convergence to a unique solution, based on iterated best response. We analyze the proposed algorithm in terms of the price of anarchy (PoA), that is, compared to a centralized optimum solution, and shown to have a moderate performance loss.

Finally, this dissertation addresses the effect of different MAC protocols and topologies in the positioning performance. In this direction, we study the performance of mesh and cluster-tree topologies defined in WSN standards. Different topologies place different constraints in network connectivity, having a substantial impact on the performance of positioning algorithms. While mesh topology allows high connectivity with large energy consumption, cluster-tree topologies are more energy efficient but suffer from reduced connectivity and poor positioning performance. In order to improve the performance of cluster-tree topologies, we propose a cluster formation algorithm. It significantly improves connectivity with anchor nodes, achieving vastly improved positioning performance.

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