Abstract of PhD Thesis

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Abstract

The main contributions of this thesis are located in the domain of wireless sensor netorks. More in detail, we introduce energyaware algorithms and protocols in the context of the following topics: self-synchronized duty-cycling in networks with energy harvesting capabilities, distributed graph coloring and minimum energy broadcasting with realistic antennas. In the following, we review the research conducted in each case.

We propose a self-synchronized duty-cycling mechanism for sensor networks. This mechanism is based on the working and resting phases of natural ant colonies, which show self-synchronized activity phases. The main goal of duty-cycling methods is to save energy by efficiently alternating between different states. In the case at hand, we considered two different states: the sleep state, where communications are not possible and energy consumption is low; and the active state, where communication result in a higher energy consumption. In order to test the model, we conducted an extensive experimentation with synchronous simulations on mobile networks and static networks, and also considering asynchronous networks. Later, we extended this work by assuming a broader point of view and including a comprehensive study of the parameters. In addition, thanks to a collaboration with the Technical University of Braunschweig, we were able to test our algorithm in the real sensor network simulator Shawn (http://shawn.sf.net).

The second part of this thesis is devoted to the desynchronization of wireless sensor nodes and its application to the distributed graph coloring problem. In particular, our research is inspired by the calling behavior of Japanese tree frogs, whose males use their calls to attract females. Interestingly, as female frogs are only able to correctly localize the male frogs when their calls are not too close

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in time, groups of males that are located nearby each other desynchronize their calls. Based on a model of this behavior from the literature, we propose a novel algorithm with applications to the field of sensor networks. More in detail, we analyzed the ability of the algorithm to desynchronize neighboring nodes. Furthermore, we considered extensions of the original model, hereby improving its desynchronization capabilities.To illustrate the potential benefits of desynchronized networks, we then focused on distributed graph coloring. Later, we analyzed the algorithm more extensively and show its performance on a larger set of benchmark instances.

The classical minimum energy broadcast (MEB) problem in wireless ad hoc networks, which is well-studied in the scientific literature, considers an antenna model that allows the adjustment of the transmission power to any desired real value from zero up to the maximum transmission power level. However, when specifically considering sensor networks, a look at the currently available hardware shows that this antenna model is not very realistic. In this work we reformulate the MEB problem for an antenna model that is realistic for sensor networks. In this antenna model transmission power levels are chosen from a finite set of possible ones. A further contribution concerns the adaptation of an ant colony optimization algorithm –currently being the state of the art for the classical MEB problem– to the more realistic problem version, the so-called minimum energy broadcast problem with realistic antennas (MEBRA). The obtained results show that the advantage of ant colony optimization over classical heuristics even grows when the number of possible transmission power levels decreases. Finally we build a distributed version of the algorithm, which also compares quite favorably against centralized heuristics from the literature.

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