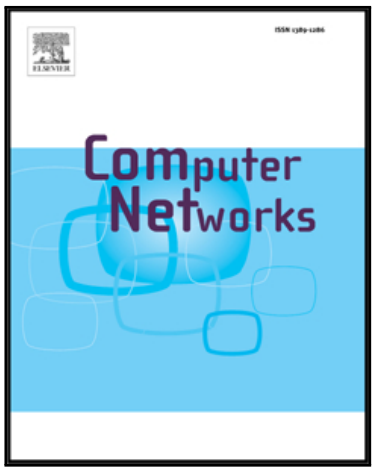

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An Evolutionary Routing Game for Energy Balance in Wireless Sensor Networks

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Abstract

In a Wireless Sensor Network (WSN), the sensor nodes rely on each other to forward packets from the origin to the base station via some routes. Computation of a desirable route is challenging. Some of the routes can be better than others, which might lead to an imbalance in contention for disparate routes as one route may be congested more frequently or exhausted quicker than the others. Since each node's self-interest is to save its own energy due to the limited energy resource, it can lead to congestion resulting in higher delays and additional packet collisions– which may eventually result in quicker energy depletion along such routes and shorten the lifespan of the network. In this paper, we analyze this issue from a game theoretic perspective and model the route selection problem in a WSN as an evolutionary anti-coordination routing game. We derive the evolutionary stable strategy (ESS) of the game and prove that the derived incumbent strategy cannot be invaded by a greedy strategy i.e., mutant strategy. Furthermore, we derive the replicator dynamic of the proposed game in order to show the behavior of the sensors in selecting the paths. The mechanism of the replicator dynamics also shows how the nodes learn from their strategic interactions and modify their strategies at every stage of the game until reaching a stable strategy (ESS). Furthermore, the evolutionary game can be implemented in a distributed manner. Finally, in order to achieve increased lifetime, we analyze the fairness of the proposed equilibrium solution under the selfish node behavior by utilizing Jain's fairness index. The results show that the proposed system is successful in converging the strategy choices to ESS even under dynamic conditions.

Keywords: Wireless Sensor Networks, Energy Efficient, Evolutionary Game Theory, Congestion, Stable Strategy, Fairness

1. Introduction

With the rapid advancements in wireless technology, Wireless Sensor Networks (WSNs) are being widely deployed. A WSN consists of hundreds or even thousands of heterogeneous

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