

# Improvement of Mobile Relay for Prolonging the Lifetime of Wireless Sensor Network

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## 1. Introduction

Mobile relay for Wireless Sensor Network (WSN) utilizes mobile nodes, which are sensor nodes with mobility, in order to save the energy consumption on WSN. In mobile relay, given the relaying sequence of mobile nodes as an initial route, the mobile relay algorithm determines the optimal positions of the relaying nodes in terms of the total energy consumption of wireless transmission and locomotion. The achievable energy efficiency greatly depends on the used initial route. Further, in order to maximize the network lifetime of WSN, nodes' battery levels should be taken into account. Firstly, in order to maximize the network lifetime, this dissertation investigated effective initial route construction methods. Secondly, in order to make mobile relay applicable for large scale networks, this dissertation developed a distributed algorithm of initial route construction.

## 2. Results and Discussions

Firstly, for the case of single source node, two types of initial route construction methods were presented. Both methods take into account nodes' battery levels. The first type, BAIR (Battery-Aware Initial Route construction), is based on a greedy approach, which is suitable for distributed implementation. The second type is BAIR-D (Battery-Aware Initial Route construction based on Dijkstra's Algorithm), which can always find an optimal route in terms of a given cost function. The numerical simulation results show that BAIR and BAIR-D outperform the conventional methods in terms of the network lifetime. In particular, BAIR-D improves dramatically the lifetime of the network and achieves a 100% successful rate in route construction.

Secondly, for the case of multiple source nodes, an effective initial route construction method was presented. In a case of multiple sources, if initial route construction is performed independently for each source, then the constructed paths are necessarily overlapped. A solution to this is BMRC-POA (Battery-aware Multiple Route Construction with Path-Overlap Avoidance), which avoids the path overlap whenever possible. The numerical simulations show the effective routing order of the multiple sources and demonstrate that BMRC-POA achieves approximately 25% improvement of the network lifetime against BAIR-D.

Finally, a distributed algorithm of initial route construction was presented. Obtaining an optimal initial route requires the global information on the entire network. This, however, involves a large number of communications in initial route construction. In order to reduce the number of communications required for initial route construction, BAIR-A\* (Battery-Aware Initial Route construction based on A-Star algorithm) was presented. The proposed heuristic cost function used in BAIR-A\* effectively estimates the actual cost by using the expectation of the communication distance per-hop and the remaining battery levels. Then, a distributed algorithm of BAIR-A\* was presented. The numerical simulations show that BAIR-A\* can construct the same initial routes as BAIR-D for most cases and BAIR-A\* can significantly reduce the number of communications required for initial route construction.

## 3. Conclusions

This dissertation investigated effective initial route construction methods from the viewpoints of network lifetime and implementation issues. The effectiveness of the proposed methods was demonstrated by numerical simulations.