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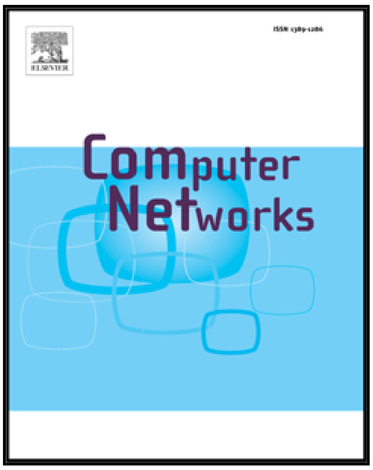

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Energy Efficient Collaborative Proactive Routing Protocol for Wireless Sensor Network

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Abstract*— A Wireless Sensor Network (WSN) is a group of tiny power-constrained nodes that cover a vast region of interest (ROI), sense and communicate it to the Base Station (BS). The main challenge encountered in WSNs is how to cover the ROI perfectly and transmit the monitored data to the BS for the longest possible time. Although many energy-efficient routing protocols for periodic monitoring applications were recently introduced, the dynamic nature and complex environments of WSN applications make building such protocols a considerable challenge. In this paper, the node degree of the Degree Constrained Tree (DCT) in homogeneous proactive WSN is studied analytically for the network with one BS that is outside the ROI. Since the node degree affects the network lifetime of these types of networks, the optimum node degree for minimum energy consumption in DCT is derived. Subsequently, the paper proposes a Collaborative Distributed Antenna (CDA) routing protocol that is based on distributed antenna theory to provide fair load distribution in terms of transmission energy. CDA is based on DCT with optimal node degree and is designed for periodic data monitoring in WSN applications. The experimental results prove our analysis to emphasize that using optimal node degree in DCT doubles its network lifetime compared to using other node degrees. Moreover, adding CDA to DCT with optimal node degree is proved to double the network stability period and reduce the ratio between instability period and the network lifetime to its half. It also shows 25% increase in network lifetime and minimum rate of node loss compared to its peers, such that the lifetime of half the nodes is preserved until few rounds before the end of network lifetime.

Keywords Wireless Sensor Networks, Homogeneous Networks, Monitoring Applications, Proactive Routing, Degree Constrained Tree, Distributed Antenna

1 Introduction

A sensor network is a number of tiny sensor nodes of low costs that cover a certain Region of Interest (ROI) to measure data using different sensing capabilities and transmit them to the base station (BS). To minimize power consumption in data transmission, it is preferable to use multi-hop transmission to reach the BS instead of direct transmission, especially in large ROIs with only one BS. Consequently, the computational and communication tasks of sensor nodes may divide them into three main types according to their role in the ROI, which are sensor nodes, routers, and relay nodes. These three main types may vary physically as in the heterogeneous or hybrid networks; unlike homogeneous networks, as discussed by Abdul-Salaam *et al.* in [1].

The lack of energy fairness in multi-hop routing, especially when BS is far from the ROI that is monitored by homogeneous WSN, leads to losing the nodes that are responsible for ROI to BS transmission. Accordingly, the nodes in ROI become disconnected from the BS. Thus, the need for self-organized networks encourages researchers to introduce different dynamic routing protocols to avoid this issue. For example, Elsayed *et al.* introduced a distributed self-healing approach called DSHA that was designed for clustered network architecture in [2]. This recovery algorithm works at both network levels, sensor node levels, and cluster head levels. The authors utilized DSHA to overcome the challenge of energy loss and sudden failures of hardware components to extend WSN lifetime. However, these protocols produce relatively high network overhead, as studied in [3], unlike static routing protocols.

In contrast, static routing protocols with single setup phase suffer from the premature end of network lifetime. It is typical when BS is far from the ROI, due to losing the nodes that connect the BS to the ROI, which are the first nodes to drain their energy in the network. This problem was discussed in [3]; however, the choice of the degree of the DCT [4] that was the base of the energy-aware algorithms OHCR and OHA was not analytically justified. In literature, the end of WSN lifetime has been defined from the different point of views to describe