

PATH COST BASED LOAD AND ENERGY BALANCED CLUSTERING & ROUTING ALGORITHM

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ABSTRACT

The design of efficient clustering and routing algorithms is crucial for Wireless Sensor Network (WSN) applications. Many existing algorithms for clustering and routing suffer from uneven load distribution, which can significantly impact network performance. In order to extend the network lifetime, it's essential to consider energy consumption in routing. When determining the routing path, factors such as residual energy, distance, back transmission, and the current load of gateways must be taken into account.

In this study, we introduce PBLBC (Path cost based Load Balanced Clustering and Routing Algorithm), which addresses these challenges. Firstly, we propose a clustering algorithm that is both energy-aware and load-balanced. In this algorithm, gateway selection is based on a cost function. Subsequently, we present a routing algorithm where the next-hop gateway is chosen using a path cost function. Simulation results demonstrate the effectiveness of the proposed algorithm.

Keywords: Wireless sensor networks; clustering; energy efficiency; load balancing; PBLBC

1. INTRODUCTION

Wireless Sensor Networks (WSNs) find applications in various fields such as disaster warning systems, environmental monitoring, healthcare, military surveillance, and home automation, among others. Their versatility has attracted the attention of numerous researchers. A typical WSN consists of numerous small nodes or sensor nodes deployed randomly in a selected target area. These nodes are equipped with power units and components for communication, data sensing, and processing. After gathering local information, sensor nodes transmit data to a base station, also known as a sink. However, a significant challenge with WSNs is their limited energy capacity. Operating on low-power sources, these nodes often deplete energy quickly, making it difficult or impossible to replace them. Researchers continuously study these issues to develop efficient WSN designs. Clustering algorithms have emerged as promising solutions for improving energy efficiency in WSNs. In cluster-based algorithms, nodes are grouped into clusters, each with a cluster head (CH).

These CHs aggregate local data and transmit it to the base station. In many WSNs, cluster head selection is performed among normal nodes, which have limited energy and a short lifespan. To address this, researchers propose using gateways or relay nodes as CHs. Gateways typically have more energy capacity than normal sensor nodes, but they are also battery-operated, introducing power constraints.

Therefore, the longevity of gateways is crucial for the network's long-term operation. Improper cluster formation can overload some gateways, reducing the network's lifetime. Thus, cluster formation should aim for both energy and load balancing to enhance network longevity. Several researchers have proposed load balancing algorithms based on the number of nodes assigned to each gateway. However, they often overlook considering the residual energy of gateways in load calculations. This oversight can impact the network's performance and longevity.

2. OBJECTIVE OF THE WORK

Several clustering algorithms have been developed for WSNs. LEACH is among the most popular ones, operating on the principle of rotating cluster heads (CHs) among sensor nodes to balance the load. However, LEACH's main drawback lies in CH selection, which is based on probability and may result in nodes with minimal energy being elected as CHs. Additionally, LEACH's communication between CHs and the base station occurs via single hop, which is impractical for large networks. Improved algorithms like HEED, PHGASIS, and TEEN have been developed over the years to address these shortcomings. HEED is a distributed clustering scheme that selects CHs based on residual energy and intra-cluster distance. P. Kuila et al. proposed a distributed clustering and routing algorithm that worked well for multi-hop routing but lacked load balancing. Mounir Arioua et al. introduced a multi-hop cluster-based routing approach combining LEACH and MTE protocols, yet load balancing was not considered. K. Biswas et al. utilized heuristic measures to establish energy sufficiency and efficiency, but their algorithm sometimes experienced increased delays due to unrestricted next-hop selection. Zhu Yong et al. presented DECSA (Distance Energy Structure Algorithm), which considers residual energy and node distance but overlooks existing CH load

during multi-path routing. Most of the aforementioned algorithms focus on either clustering or routing issues individually, with few considering both simultaneously, and none ensuring load balancing. The proposed algorithm in this article tackles clustering and routing issues comprehensively, with a focus on load balancing as well.

3. NETWORK MODEL AND TERMINOLOGIES

We make the assumption that both sensor nodes and gateways are deployed randomly and become stationary after deployment. Sensor nodes can only be assigned to gateways within their communication range. Thus, each sensor node has a set of potential gateways it can be assigned to, with each node assigned to only one gateway from this set.

A round is defined as a complete period involving data gathering and transmission of aggregated data from all relay nodes to the sink. The network's lifetime is measured by the number of rounds until the first gateway failure. All communication occurs over wireless links, established only between sensor nodes within each other's communication range.

4. CONCLUSION

This paper introduces an energy and load balanced clustering and routing algorithm tailored for wireless sensor networks (WSNs). The algorithm designates less energy-constrained nodes as gateways acting as cluster heads. During the cluster formation phase, non-cluster heads are assigned to gateways within their communication range, taking into account gateway selection cost. The proposed algorithm achieves both energy and load balance.

In the multi-hop routing phase, the algorithm selects the optimal gateway based on path cost. Each gateway calculates the path cost solely for gateways within its communication range. Experimental results demonstrate that the algorithm efficiently balances energy consumption and enhances network lifetime.

Our algorithm is designed for static environments without node mobility. Future work will focus on developing algorithms considering node mobility while maintaining effective energy consumption balance.

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