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AN APPROACH FOR ENERGY-EFFICIENT CLUSTERING USING WIRELESS ENERGY BALANCER

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Abstract— One of the most effective methods for preserving the energy of wireless sensor networks (WSNs) has been recognized as clustering. The cluster heads (CH) in cluster-based WSN consume more power Compared to conventional nodes, they use more energy, which raises their energy consumption and shortens the network lifetime. There are a number of energy-efficient routing strategies that have been proposed to lower CHs' energy usage. The energy consumption of CHs will decrease in such designs as they are farther clustered. This criterion, however, was not taken into account in earlier related publications. The imbalanced energy consumption of CHs is another major design issue that contributes to increased energy loss and early network death. Several recent researches have attempted to balance the energy by using equipment with huge and expensive energy harvesters, which results in additional costs. Therefore, a workable solution is required to ensure that CHs consume energy in a balanced manner. As a result, in order to get beyond the aforementioned restrictions, we put forth an architecture for energy-efficient clustering that makes use of a wireless energy balancer. First, an n-level clustering that completely utilizes and lowers the energy consumption of CHs is given. Second, by bringing the difference between the remaining energy of CHs to zero, an energy balancer is used to minimize the wasted energy to the fullest extent possible. The proposed scheme's performance has been contrasted with that of the CMS2TO and DGOB methods. The results of the simulations demonstrate that the suggested scheme outperformed previous schemes. In conclusion, the suggested framework demonstrates that it is an effective way to increase the network lifetime and energy efficiency than CMS2TO and DGOB.

Keywords*:* Wireless sensor network, clustering, wireless energy balancer, energy efficiency.

I. INTRODUCTION

Multiple sensor nodes make up a Wireless Sensor Network (WSN), which is in charge of sensing data (such as video, sound, temperature, etc.) and sending it to a Base Station (BS).One of the most difficult problems in WSNs, energy limiting of sensor nodes, has a detrimental effect on the network longevity. In order to solve the energy limitation issue, a number of energy-efficient based solutions have been proposed. One of the best ways to increase energy efficiency and network lifetime is by clustering. The network region is separated into in cluster-based WSNs. A Cluster Head (CH) node and numerous Member Nodes (MN) make up each of the many clusters. The sensed data are transmitted from MNs to CHs in this form of network, and from CHs to BSs. By limiting the data transmission range of MNs and lowering their energy usage, clustering typically improves energy efficiency. In such plans, CHs are taken into account as the controlling entity that performs a symbolic function throughout data collection and transmission. Since CHs serve as the hub for all activity inside a cluster, they are frequently overburdened with data traffic and are susceptible to rapid energy depletion. These studies can be broadly categorized into three groups: inter-cluster routing-based schemes, CH election-based methods, and cluster size optimization-based techniques. In WSNs, there are typically two groups of clustering routing protocols: single-hop and multi-hop inter-cluster routing methods. In single-hop, the BS is the only point of contact for all CHs. However, CHs use data relaying in the inter-cluster multiple-hop routing method. The following is a summary of the proposed work's primary contributions:

1. In contrast to the majority of previous studies, the clustering advantages in this work are completely utilized by implementing the clustering on CHs, which results in decreased energy consumption. In other words, the CHs frequently cluster up until data packets reach the BS.
2. The majority of the current research has the potential to somewhat minimize the volatility in node lifespan. To our knowledge, no other authors have, however, managed to attain zero variance of CHs' energy. Therefore, creating a workable way to get around this restriction is still necessary. As a result, an energy balancer node is used to balance CHs' energy until there is zero variation.
3. The suggested work is evaluated against alternative methods in a dynamic environment using a variety of network metrics.

II. Literature Survey

Numerous studies have been conducted to lower CH energy usage through cluster attribute optimization. This section's subsection provides a review of the research on cluster-based protocols that aim to improve the energy efficiency of CHs.

By considering residual energy, buffer length, and received signal power parameters during the CH election process, [1] writers try to lower the energy consumption of CHs. According to the results of the simulation, taking these characteristics into account resulted in CHs using less energy and a longer network lifetime.

The given Energy Efficient Multi-hop Cluster-head Election approach (EEMCE) seeks to shorten the distance between CHs and BS, which lowers CHs' energy consumption. In order to do this, [2] writers factor the distance between nodes and BS into the CH election procedure. At each cluster, a tentative CH is first selected, and the remaining energy of the tentative CH is then compared with other nodes in the same cluster. The node with the highest amount of leftover energy will ultimately be selected as the CH. Additionally, for the CHs located at the network's edge, a multi-hop data transmission method will be used to lower the energy consumption of CHs.

The proposed improved energy optimization routing protocol (EEORP) aims to lower network and CH energy usage. In EEORP [3], a grid-based CH election algorithm is proposed that takes into account the declaration number order weight and energy weight factors in an effort to consume less energy.

A Gateway Clustering Energy-Efficient Centroid (GCEEC) based routing protocol is modeled [4] with the intention of extending network lifetime by reducing CH nodes' energy consumption. In this architecture, each cluster also uses a gateway node in addition to the CH nodes. In actuality, gateway nodes use multi-hop communication to transmit data from CHs to the BS, maximizing CH coverage and lowering CH transmission power. In GCEEC, the CH nodes are chosen from the nodes at the cluster's centroid regions, while the gateway nodes are chosen from the nodes at the cluster's edge regions.

To address the issue of excessive energy consumption of CHs, a grid clustering-based multi-hop routing technique [5] is developed. In such a strategy, the election of functional nodes is optimized by integrating criteria such as node remaining energy, node location, and levels of the network area in order to reduce energy usage. This method lessens the workload of the CH nodes by using communication nodes to choose the CHs and send data packets via multi-hop routing between clusters.

Additionally, a hybrid meta-heuristic approach that maximizes the load-balanced of CHs combines [6, 7] the advantage of artificial bee colonies and differential evolution is described. In order to achieve this, an objective function is modeled using the parameters of average energy, intra-cluster distance, and delay. The authors then presented a meta-heuristic technique to enhance the mobile BS's sojourn location. The proposed approach improves the remaining energy and network lifetime while lowering average and total energy consumption, according to the results of the simulation.

III. System Study

The system model for the suggested algorithm's development is presented in this section along with some presumptions. Assume that the m x m square network model contains N heterogeneous rechargeable sensor nodes that are randomly distributed. Each node has limits on its available energy, memory, and transmission power. The sensor nodes in our proposed system are outfitted with RF Wireless Power Transfer technology, allowing them to wirelessly send energy. The nodes can also collect energy from other nodes because they are outfitted with rechargeable batteries in a similar manner. Comparing the BS to sensor nodes reveals its superior strength. Additionally, the clustering technique is used to lower the energy consumption of the sensor nodes. The CH in each cluster is chosen based on its proximity to other nodes and is in charge of gathering data from MNs and transmitting it to the BS deployed outside of the network area. Additionally, a wireless energy balancer (WEB), a portable power bank with a larger battery capacity, is used to achieve balanced energy of nodes. WEB is able to receive and transmit power to the sensor nodes. The WEB and sensor nodes are employed as the transmitter and receiver in a two-way relationship in the energy transmission paradigm from.

2.1. CHs algorithm's n-LEVEL CLUSTERING

Under order to lower the energy consumption of sensor nodes, clustering is a viable approach; however, under the clustering technique, CHs consume more energy than regular nodes, shortening the network lifetime. Therefore, n-level clustering of CHs is used, which results in a decrease in CH energy consumption and an increase in energy efficiency and network longevity. In contrast to earlier cluster-based systems,

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the proposed clustering technique constantly applies the clustering technique to CHs while data is being transmitted from a node to the BS until the data packets reach the BS. Each clustering level generally has two parts in the proposed algorithm: cluster formation and CH election. The next subsections provide descriptions of these two phases. Additionally, Algorithm 1 describes the comprehensive algorithm in depth.

Algorithm

Input: no: level of clustering
Node: number of nodes
//First level clustering
1. NC(i)=D 4^{no-1} //calculating the number of clusters
2. Z =Node/NC; //the network is divided into NC clusters
3. Repeat w from 1 to NC
3. Repeat p from 1 to Z
4. Repeat q from 1 to Z
5. d(i)=distance (p, q) // calculating the distance between nodes
6. End of q
7. End of p
8. CH(w)=min(d); // selecting the proper CH with minimum distance to other nodes
13. End for loop w
14. CHs collects data packets from cluster members
//second to the nth level clustering
15. Repeat s from 2 to no
16. NC(s) D 4^{no-s} //the network is divided into NC clusters
17. Repeat w from 1to NC
18. Repeat p for 4 times
19. Repeat q for 4 times
20. d(i)=distance (p, q)
21. End loop for q
22. End loop for p
23. CH(w)= min(d);
24. End for loop w
25. CHs collect data packets from former CHs
26. End for loop s
27. the last CH sends data packets to the BS

2.2. ENERGY BALANCER BASED WIRELESS ALGORITHM

One of the main causes of the early network mortality is the CHs' unbalanced energy consumption. The energy efficiency and network longevity are improved by using a method to balance the energy consumption among CHs. Several investigations have recently concentrated on enhancing the balanced energy through the employment of mobile devices, which are accountable for recharging the sensor nodes' batteries. Such plans incur additional costs since they make use of enormous, pricy energy harvesters to salvage the necessary energy from wave farms, solar satellites, or nuclear fusion. In order to exchange energy with the sensor nodes, we need a mobile device with a larger battery capacity known as the Wireless Energy Balancer. According to the suggested plan, WEB is in charge of balancing the CHs' remaining energy. The used WEB will travel along CHs in a planned path in order to wirelessly receive or send energy. The WEB node must priorities meeting the needs of the CH with the lowest energy level. An average CH energy level is used as a reference energy value to balance the CH energy level. If a CH's energy level is higher than this reference value, WEB will receive that CH's difference energy level; on the other hand, if a CH's energy level is lower than the reference value, WEB will transmit that CH's difference energy level.

2.3 PERFORMANCE EVALUATION

This section compares the performance of the proposed strategy to previous schemes that were proposed. As a simulator tool for our experiments, we used NS2. A 100 m x 100 m network region has 112500 heterogeneous nodes distributed consistently and at random. All of the nodes have a starting energy of 2k. The transmission distance is 25m. The WEB in use travels at a pace of 0.7 metres per second. The effectiveness of the suggested method is assessed using various evaluation indicators.

Table 2.1 No of Nodes and Network Lifetime values

	Network Lifetime		
Algorithms / No of Nodes	**Proposed Framework**	**CMS2TO**	**DGOB**
50	900	800	700
150	850	780	720
250	820	750	700
350	810	730	700
450	800	700	690

Additionally, in Table. 2.1 debits the network lifetime in three distinct ways as the node count rises. The duration of the network lifetime is when the first node in the network runs out of energy. As demonstrated, our suggested system has a longer network lifetime compared to two other works because it uses an energy balancer in addition to n-level clustering, which results in CH energy consumption that is both balanced and lowered.

Table 2.2 Number of Nodes and Data Delivery Ratio (%) values

	Data Delivery Ratio (%)		
Algorithms / No of Nodes	Proposed Framework	CMS2TO	DGOB
50	90	80	70
150	88	80	69
250	85	79	69
350	84	78	68
450	84	77	67

In Table. 2.2, debits the data delivery ratio in relation to three distinct schemes. Increasing the number of tired nodes generally has the potential to impact data transmission performance. As a result, increasing the sensor nodes' operational time also increases the network's data transmission ratio. As can be shown, our suggested framework performs better than prior schemes in terms of data delivery ratio because it has a longer lifespan than earlier schemes.

Table 2.3 Data Delay Vs Number of nodes

	Data Delay (MSEC)		
Algorithms / No of Nodes	Proposed Framework	CMS2TO	DGOB
50	0.42	0.4	0.3
150	0.44	0.4	0.32
250	0.5	0.42	0.35
350	0.55	0.43	0.4
450	0.6	0.5	0.42

In Table. 2.3, three schemes' end-to-end delays have been assessed. As shown, our suggested framework's end-to-end data transmission delay is less than that of two other approaches. CMS2TO uses direct data transmission, which has a high communication cost and transmission delay in large-scale networks, to communicate between CHs and mobile sinks. Additionally, the end-to-end data delay increases in the DGOB scheme due to the construction of a lengthy routing chain between the sensor nodes and the base station, which lowers network performance. The total amount of node energy that remains after the network lifetime but is not used up is defined as wasted energy. While other sensor nodes in a WSN have enough energy to complete their tasks, sensor nodes with imbalanced energy consumption die out early. Therefore, improving the nodes' balanced energy consumption results in longer node operating times and less wasted energy. The wasted energy of CHs is reduced in our suggested framework by using an energy balancer and zeroing the variation of CHs' energy. However, after the network lifetime is over, a negligible percentage of MN energy will remain unused.

3. Results and Conclusion

With the help of wireless energy balancers, we have tried to establish a framework for energy-efficient clustering in this study. The suggested structure helps accomplish CHs' decreased and balanced energy consumption, which improves network lifetime and lowers energy waste. An n-level clustering has been added in the first phase of the framework to apply clustering on CHs, which stops CHs from using too much energy and increases network lifetime. Similar to the first segment, an energy balancer has been used in the second section. Its job is to balance energy consumption, which reduces wasted energy and zeros the variance of CHs' remaining energy. To replicate the suggested framework, we used NS2.We evaluated the proposed method's performance using various assessment indicators. The findings showed that, when compared to CMS2TO and DGOB methods, the suggested strategy is more effective. Additionally, it is recommended that future experiments outfit the energy balancer with an energy harvester to attain permanent network lifetime.

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