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Optimization Network Lifetime Through Residual Energy-Based Cluster Head Selection in IoT-Enabled WSNs

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ABSTRACT

Wireless Sensor Networks (WSNs) have gained an emerging importance in different application domains especially in event tracking and monitoring. The sensor nodes in WSNs are observed to have shorter lifetime due to the continuous sensing and processing operations that result in quicker energy depletion. Small, inexpensive, low-power, multipurpose nodes that are connected to one another form the basis of WSNs. Efficiently gather & communicate data to a washbasin. Cluster Heads (CHs) are used in cluster-based approaches to effectively arrange WSNs for data collection and energy conservation. A CH collects data from cluster nodes and aggregates/compresses it before sending it to a sink. The node's greater responsibility does, however, result in a higher energy drain, which leads to uneven network deterioration. This is made up for by LEACH (Low Energy Adaptive Clustering Hierarchy), which probabilistically alternates CH roles among nodes with energy over a set threshold. CH selection in WSN is NP-Hard because optimal data aggregation with effective energy savings cannot be done in polynomial time. To improve system performance, the synchronous firefly approach, a modified firefly heuristic, is introduced in this paper. A thorough simulation shows that the suggested method performs better than LEACH and energy-efficient hierarchical clustering. In today's world of intelligent networks, the internet of things (IoT) and industrial IoT (IIoT) are extremely important, and they fundamentally use a wireless sensor network (WSN) as a perception layer to collect the necessary data. The difficulty here is the usage of minimal energy for processing and communication. This data is processed as information and sent to cloud servers through a base station. The lifespan of WSNs is increased by the dynamic generation of cluster heads and energy-conscious clustering strategies.

Keywords: Internet of Things (IOT), Wireless Sensor Networks, Energy Efficient Routing, Clustering Hierarchy.

I. INTRODUCTION

WSNs are composed of small sized tiny devices called as Sensor Nodes (SNs) which senses the surrounding environmental parameters and transmits the information to the Base Station (BS). In general, the sensor nodes consume more energy during the data transmission and reception rather than sensing and processing. More energy is required by the SNs for transmitting the data to the Base Station when it is located at longer distance [1]. As the distance increases or data rate increases, the energy of sensor nodes depletes quickly and results in the decreased network lifetime. WSNs, or wireless sensor networks, are frequently employed in both civil and military contexts. It has been used for target tracking, surveillance, tracking natural disasters, biomedical applications, habitat monitoring, and building management systems. In natural disasters, sensor nodes sense and detect their environment to foretell disasters.

In biological devices, sensor surgical implants are used to assess a patient's health. Seismic sensing uses ad hoc sensors placed in a volcanic region to find earthquakes and eruptions. WSN nodes use non-rechargeable energy storage systems, making battery replacement difficult or impossible in many cases.

Energy efficiency is therefore a top priority, and implementing power-efficient practises is essential for extending sensor life. WSNs often employ sensors to keep an eye on particular locations, collect data, and transmit it to a base station (BS). depicts a typical WSN that is hierarchically structured. Some nodes chosen depending on the objective function act as Cluster Heads (CH) & collect data from all of their neighbours in a hierarchical structure to conserve energy. The data is subsequently sent from the CH to the BS, resulting in less network overhead and node energy savings [3].

Contrary to conventional systems, WSNs have unique design and resource constraints, such as limited energy, shorter transmission distances, constrained bandwidth, and minimal processing power in nodes. The environment and deployment strategy have an impact on the network's size. One of the most important processes in WSN is data aggregation, which is the process of collecting data from numerous sensors, combining the information, and decreasing redundant transmission. Hierarchical techniques have shown to be highly successful in data aggregation.

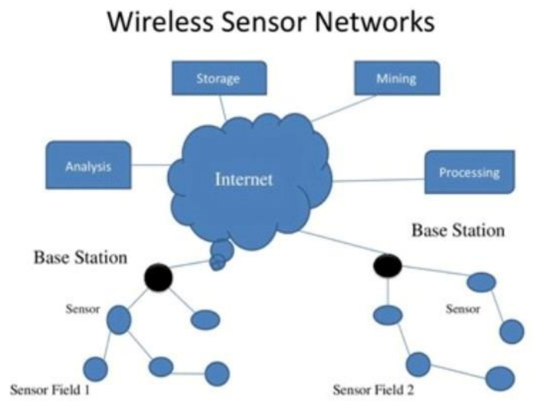

Figure 1: Architecture of Wireless Control Networks

WSNs became the backbone of all the smart IoT applications, and their reliable deployment is very important for diverse real-time applications like the military, industry, wide-area surveillance, environmental monitoring factors, and health monitoring. WSNs play an important role in the industry 4.0 revolution and they are essential in the perception/sensing layer of IoT systems for sensing the physical environment and collecting the data using WSNs.

II. CONTRIBUTIONS

Energy-efficient methods must be designed and put into practise in order to improve the major performance characteristics due to the restricted resources of SNs in WSNs and applications where recharging or replacing the battery is not a viable alternative. Even though clustering is thought to be the most popular method for extending the lifespan of

WSNs, choosing the right CH to extend the network lifetime remains difficult. At the expense of a shorter CH lifetime, the traditional clustering-based routing algorithms enable fault tolerance, load balancing, and dependable communications. In order to get around this, researchers have been working nonstop to develop effective algorithms for routing optimisation, data collecting, and CH selection [6].

In order to reduce the amount of energy consumed for computation and communication in WSNs, an updated version of the GWO algorithm is employed to select the best CH.

The suggested protocol's performance is assessed in terms of dead node counts, energy consumption percentages, operating round counts, and average throughput. To demonstrate the effectiveness of the suggested approach, a thorough statistical analysis and simulations are performed using the average of fifteen readings for each outcome [8]. Additionally, a comparison is made with the most recent GWO-based algorithm proposals. The results of the simulation show that the suggested method works better in terms of energy conservation and a longer network lifetime.

III. LITERATURE SURVEY

One of the main objectives for WSNs is to maximise network lifetime by using energy efficiently. By creating an energy-efficient process for CHs selection, clustering is known to be one of the effective approaches used in WSNs to increase energy efficiency.

Optimization of network lifetime is a critical challenge in IoT-enabled wireless sensor networks (WSNs), where the limited energy resources of sensors need to be managed efficiently to prolong network operation. In recent years, various approaches have been proposed to optimize network lifetime, including cluster-based protocols, which group sensors into clusters and elect a cluster head (CH) to manage communication and data processing tasks [5]. One such approach is residual energy-based CH selection, which selects the CH with the highest residual energy level to optimize network lifetime. In this literature survey, we will review recent studies that have investigated this approach in IoT-enabled WSNs.

Energy Efficient Techniques for WSNs

As individual SNs work with restricted energy sources and optimising the energy consumption of SNs has been a difficult design issue in WSNs, energy efficiency is a crucial aspect that must be addressed. Network stability is a vital component of guaranteeing long-lasting and dependable network coverage, and energy-efficient WSNs compromise on this aspect. For SNs in WSNs to consume energy effectively, clustering and routing must be taken into account. The network's coverage and longevity are enhanced via adaptive hierarchical routing and hybrid clustering based on the fuzzy C-means approach, residual energy, BS location, and Euclidean distance. The network lifetime is increased by the energy-efficient routing capabilities offered by fuzzy-based clustering [2].

Equalised CH election routing increases network longevity and guarantees balanced energy conservation. In order to create energy-efficient clusters and CHs, a neuro-fuzzy-based energy-aware clustering in WSNs that consists of neural networks and a fuzzy subsystem is proposed. Based on residual energy, transmission range, and trust factor (for security), these systems' performance is evaluated. Multi-level route aware clustering reduces the amount of routing control packets and limits the amount of energy used by relay nodes located close to the BS [4]. In WSNs, cluster formation based on the Voronoi diagram reduces the amount of energy used for communication. Comparing this approach to SEP, the FND can be improved by 14.5%.

Role of GWO Algorithm in Optimal CH Selection

The best CH choice utilising GWO significantly improves network performance in terms of network longevity, coverage, throughput, energy use, and WSNs. It develops the weights for the objective function depending on the CH and intra-cluster distance. Sink distance, residual energy, and balance factor. By creating an ideal fitness function, GWO tackles clustering and routing concerns by minimising the number of hops and overall distance travelled as well as achieving load balancing [7]. In comparison to the GA and PSO algorithms, the fitness functions for routing and clustering produce greater values. Effective cluster formation, dynamic CH selection, and the ideal number of CHs in WSNs are all made possible by combining GWO with WOA.

IV. RESULT

In IoT-enabled WSNs, energy efficiency is a critical issue because sensor nodes are typically battery-powered and have limited energy resources. Therefore, optimizing the network lifetime of WSNs is crucial for the successful deployment of IoT applications. Residual energy-based cluster head selection can improve the network lifetime of WSNs by reducing the energy consumption of sensor nodes and prolonging the time before nodes run out of battery power. However, it may also result in unbalanced energy consumption among sensor nodes, as some nodes may be selected as cluster heads more frequently than others.

Overall, residual energy-based cluster head selection is a promising approach for optimizing network lifetime in IoT-enabled WSNs, but further research is needed to address its limitations and improve its effectiveness. The proposed work as well as existing work were simulated in MATLAB.

The number of live nodes and no were the variables utilised to analyse the network's performance. average remaining energy, throughput, and the number of packets transmitted to the base station for dead nodes. While the number of active nodes determines the network's lifespan, throughput refers to the quantity of packets that each node sends to the base station.

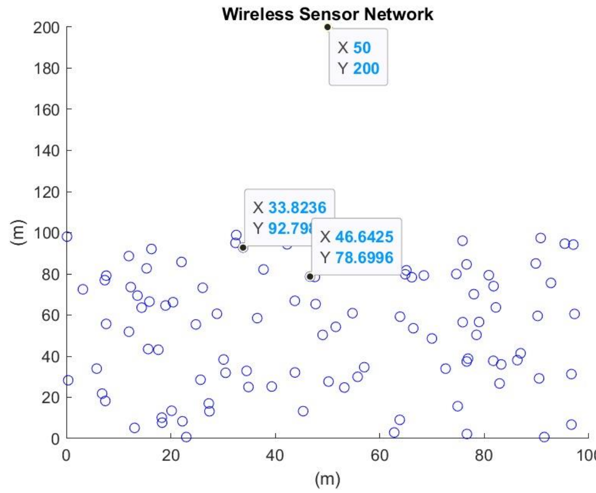

Figure 2: Deployment of nodes Wireless Control Networks

The above figure shows the nodes randomly deployed in the network.

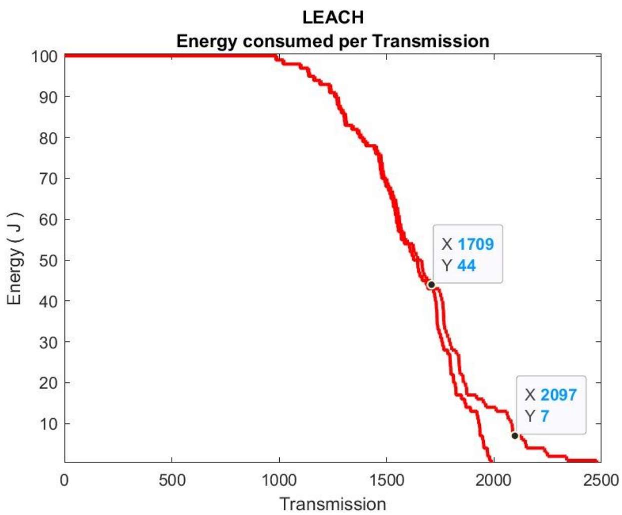

Figure 3: Comparison of Throughput against number of rounds

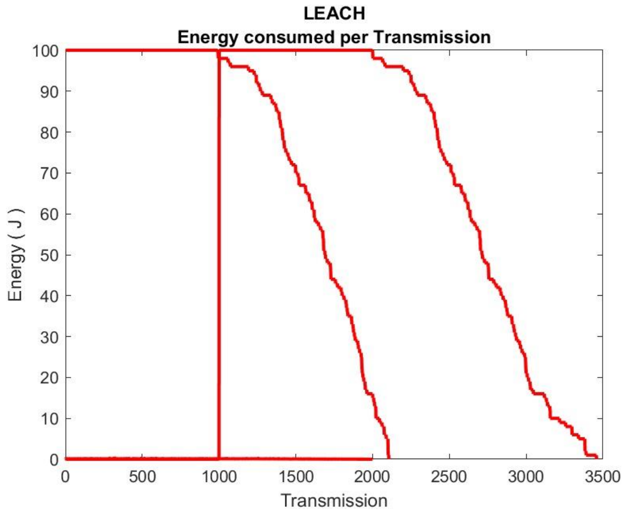

Figure 4: Average Residual Energy

The graph shows 3693 rounds is the latest output that is replaced by 1100 rounds in existing leach. That means over all network lifetime is increased. First stable period was 519 round that get hike into 1367 rounds, half node dead are in 840 and now the point is in 2031 rounds.

Overall performance is improved by 300%. These results are achieved by testing 4000 rounds for 100 nodes clustering.

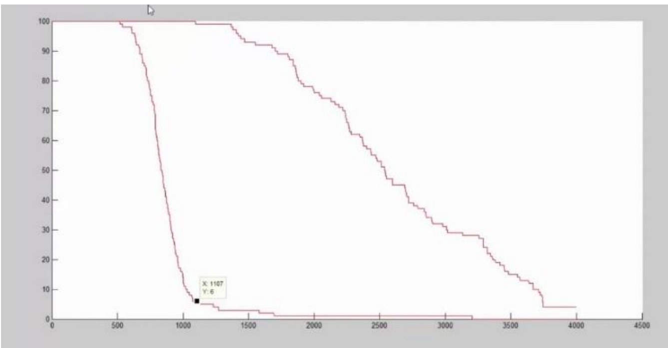

Figure 5: Final Output Comparison of Average Residual Energy against number of rounds

V. CONCLUSION

The key resource in WSNs that needs to be utilised optimally in order for the network as a whole to last longer is energy. An energy-efficient hierarchical clustering approach, which conducts three phases clustering, CH selection, and routing is presented to meet this goal. The E2HC model adaptively clusters the network initially such that nodes closer to the base station don't have to deal with a significant amount of data-forwarding overhead. The E2HC model then selects the CHs so that energy depletion is evenly spread throughout all of the cluster's nodes. As a final step, the E 2HC model routes the packets based on distances, which uses less energy. The suggested E 2HC model has demonstrated higher performance than the existing techniques in terms of energy consumption and network lifetime, according to rigorous simulation research.

The recommended method avoids multiple local optima while enabling faster convergence. Results from simulations show how effectively the proposed method reduces packet loss rate. The longevity of the network was also increased by the suggested hybrid firefly technique. Future research could examine the effect on raising a certain quality of service parameter.

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