Residual Energy Based Cluster head Selection in WSNs for IoT Application

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Abstract: WSNs are made up of small, low-cost, low-power multifunctional nodes that are linked together to effectively aggregate & transmit information to a sink. Cluster-based techniques employ Cluster Heads (CHs) to efficiently organize WSNs for data aggregation and energy savings. Before delivering data to a sink, a CH gathers data from cluster nodes and aggregates/compresses it. However, the node's increased duty causes a higher energy drain, resulting in uneven network degradation. LEACH (Low Energy Adaptive Clustering Hierarchy) compensates for this by probabilistically rotating CH roles among nodes with energy above a predetermined threshold. Because optimal data aggregation with efficient energy savings cannot be accomplished in polynomial time, CH selection in WSN is NP-Hard. In this study, a modified firefly heuristic, synchronous firefly method, is presented to increase the system performance. Extensive simulation reveals the suggested technique to operate well compared to LEACH and energy-efficient hierarchical clustering.

Keywords: Internet of Things (IOT), WSN, Energy efficiency, Firefly algorithm.

I.INTRODUCTION

Wireless Sensor Networks (WSNs) are widely used in both civilian and military settings. Target tracking, surveillance, natural disaster tracking, biomedical applications, habitat monitoring, and building management systems have all leveraged it [1]. Sensor nodes in natural disasters sense and detect their surroundings in order to predict disasters. Sensor surgical implants are used in biological devices to evaluate a patient's health. Sensors ad hoc deployed in a volcanic area detect earthquakes/eruptions in seismic sensing [2]. WSN nodes use non-rechargeable energy storage devices, battery replacement is often not feasible. As a result, energy efficiency is a major concern, and implementing power-efficient procedures is vital for extending sensor life [3]. WSNs generally use sensors to monitor specific areas, gather data, send it to a base station (BS). Figure 1 depicts a typical WSN that is organized hierarchically. To save energy in a hierarchical system, some nodes selected based on the objective function act as Cluster Heads (CH) & aggregate data from all of their neighbors. The CH then sends the data to the BS, reducing network overheads, saving energy in every node.

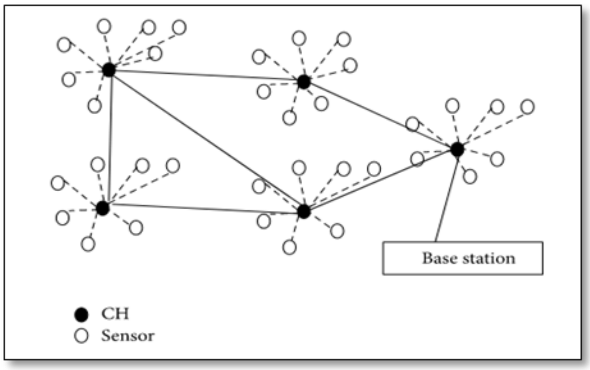

Figure 1: WSN architecture[3]

Despite typical systems, WSNs have their own set of design & resource limitations, such as restricted energy, shorter transmission ranges, limited bandwidth, and minimal processing capability in nodes. The size of the network varies depending on the deployment scheme and the environment. Data aggregation, which is the method of getting data from various sensors, fusing the information, reducing redundant transmission, is one of the most significant operations in WSN. In data aggregation, hierarchical approaches have proven to be quite effective.

LEACH uses CH to randomize node rotation, distributing energy load evenly between network sensors. The LEACH approach works on the principle that nodes become CH on a regular basis, with 2 steps for each time. Cluster construction comes first, regarding the data communication [4]. Every node chooses a random integer & matches it to threshold values during cluster creation. It is picked as CH if the number is smaller than; otherwise, it remains a regular node in that round. The criterion is set by

$$t(n) = \begin{cases} \dfrac{p}{1 - p * (r \bmod (1/p))} & \text{if } n \in G \\ 0 & \text{if } n \notin G, \end{cases}$$

where p is the percentage of the Cluster Heads over all nodes. is the round number. G is the set of nodes that have not been CH in the 1/p first rounds.

The firefly heuristic was used to conduct research in this study. A new firefly heuristic is suggested to circumvent the local minimum issue. The firefly heuristic is focused on the brightness of fireflies' light. Because the objective function is related to the intensity of light generated, low-intensity fireflies are attracted to higher-intensity fireflies. In this study, a hybrid firefly algorithm, synchronous firefly algorithm, is presented based on (i)Ranked sexual reproduction capability of chosen fireflies,(ii)the fireflies formed by this approach having the best genes from the ranked fireflies.

The suggested technique has the following benefits: (i)faster convergence, and (ii) prevention of many local optima.

This paper is organized as follows: Section II describes the literature survey of proposed work. Section III illustrates the proposed objectives and Section IV shows the experimental results obtained by using the proposed approach. Finally ,the paper concludes with Section V.

II.LITERATURE SURVEY

Behera et al.,[6] development of the current SEP that integrates a threshold-based CH selection for a heterogeneous environment. The threshold ensures that energy is distributed uniformly among member as well as CH nodes. To allocate the network load evenly, SN are classified into 3 types: normal, intermediate, as well as developed, based on their initial energy supply. According to the simulation outcomes, the suggested approach outperforms SEP as well as DEEC procedures by 300 percent in cluster formation as well as 56 percent in throughput.

Narottama et al.,[7] proposed a new method of rotating the CH avoid reduce the load on the cluster head in terms of power consumption. Clustering technology, a modern approach to D2D communication, is expected to reduce the power usage of devices. However, this method can create a significant energy load on the CH, which can lead to a serious imbalance in the ratio of energy consumed by the head to the cluster members. The authors performed several simulations to showed the superiority of cluster head rotation. Results show that rotating the cluster head offers a better power balance (1.25:1 for CH:CM) contrasted to the standard clustering method (3:1 for CH:CM). The total power consumption when rotating the CH is also 75% lower than with standard clustering methods.

Abushiba et al.,[8] CH-leach has been suggested. Authors present structures and strategies, as well as assess them. Analytical research & simulations were used to assess its effectiveness. The assessment was based on the most important WSN indicators, including energy efficiency (energy consumption) and network longevity. The suggested CH-leach uses less energy than LEACH and DEEC, according to the evaluation and comparison with existing solutions. While CH-leach improves entire system longevity by 91 percent and 43 percent over LEACH and DEEC procedures, etc.

Behera et al.,[9] concentrates on an accurate Ch election approach that turns the CH location between many nodes that have a faster speed than others. To select the next group of CH for the system that is suitable for IoT apps like environmental observing, smart cities, & devices, the technique calculates remaining energy, power consumption, and an average value of CH. Based on simulation results, the different version outperforms the LEACH approach by increasing throughput 60%, lifetime 66%, RE 64% .

Kumar et al.,[10]The use of opportunism transmissions in compartmental design-based cluster size optimization is introduced. There is a sensible enhancement of 6% and 8% in average power usage for the compartmental design when contrasted to the incremental as well as log designs, in both. The visible light signal is discovered to be 13% more effective than both the WiFi & acoustic messages. Furthermore, there is a benefit to only evaluating the second order term of the Taylor series. The current design serves as a foundation for future work on recommendation systems, malicious sensor identification as well as localization, the SGD technique in a huge WSN, and the Cramér-Rao bound for variable prediction.

Mishra et al.,[11] proposed an EE-ECHS approach based on the RE of sensor nodes. Results are performed to evaluate the performance of ECHS. The outcomes show that the suggested ECHS can provide better performance than the existing approaches.

Prasath et al.,[12] Ridge Method CH Selection (RMCHS) is a new synchronous transit technique that chooses effective CHs for the sensor nodes. RMCHS employs a new Synchronous transit method to account for CH homogeneity when balancing clusters. When compared to well-known LEACH algorithms, RMCHS clearly outperforms them in terms of residual energy, throughput, living nodes, and dead nodes.

III.PROPOSED WORK

- **Research Gap:**

The authors in the existing scheme have worked by considering LEACH as basic protocol and improved it by making modification to the way the cluster heads are elected in the network. They elect the cluster heads based on remaining energy of the nodes in the network. Also, the data transmission from cluster heads to the base station is done using single hop communication.

These two steps have separated drawbacks: first the selection of the cluster head ignore other parameters such as proximity of the node from base station or location of the node in the network etc. These parameters must be considered to optimally select the cluster heads in the network. Also, the data transmission, when done via single hop communication method, consumes more energy in the network; it can be changed to multi hop communication.

- **Objectives:**

1. To study various techniques that work to optimize the energy consumption in WSNs.

2. To optimize the cluster head selection method and data transmission method in the existing scheme using bio inspired technique.

3. To implement the proposed work in MATLAB.

4. To compare the performance of the proposed and existing work based on number of alive nodes, number of dead nodes, residual energy and throughput of the network.

- **Research Methodology:**

The proposed cluster head selection method will be done using firefly optimization. It is the method derived from the behavior of fireflies which get attracted to the other flies based on the amount of light emitted by them. The amount of light/brightness is usually computed by attractiveness factor. In the proposed work, the optimal cluster head will be the one that has higher attractiveness as compared to the other nodes. The attractiveness will be computed using the fitness function of the nodes; the fitness function will depend upon the energy and position of the node with respect to base station.

Once the cluster heads have been selected optimally, these will form clusters with other nodes in the network. After cluster formation, the members will aggregate their data at cluster heads. These heads will now have to forward data to the base station. Instead of sending the data to the base station directly, we will use multi hop communication in which the cluster heads will forward the data to base station via other cluster head; the relay cluster head will in turn will be selected based on firefly optimization again. Here the attractiveness of the nodes will be computed based on proximity of the head from the base station.

IV.RESULTS

The proposed work as well as existing work were simulated in MATLAB. The simulation was conducted in network area of 100 sq meters and a total of 100 nodes were randomly deployed in the network. The various simulation parameters used for the simulation are given in the table below:

Table 1: Simulation Parameters

Parameter	Value
Channel	Wireless
Number of Nodes	100
Network area	100 * 100 sq meters
Base station location	(50,50)
E_{elec}	50 nJ/bit
E_{da}	5 nJ/bit/message
E_{amp}	0.0013 pJ/bit/m^4
E_{fs}	10 pJ/bit/m^2
Packet Size	4000 bits
Initial energy	0.5 Joules

The parameters used to analyzed the performance of the network were number of alive nodes, no. Of dead nodes, average residual energy and throughput (i.e. number of packets sent to the base station). While number of alive nodes determine the lifetime of the network, the throughput defines the number of packets sent by the nodes to the base station.

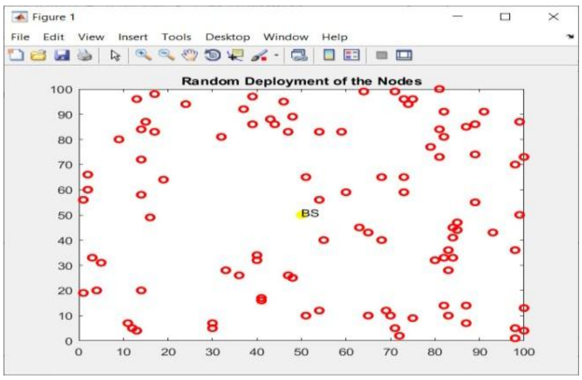

Figure 2: Deployment of the nodes

The above figure shows the nodes randomly deployed in the network. The nodes are deployed in the region of 100 * 100 sq meters. The base station is location at 50,50. These nodes generate the random number and forms cluster head.

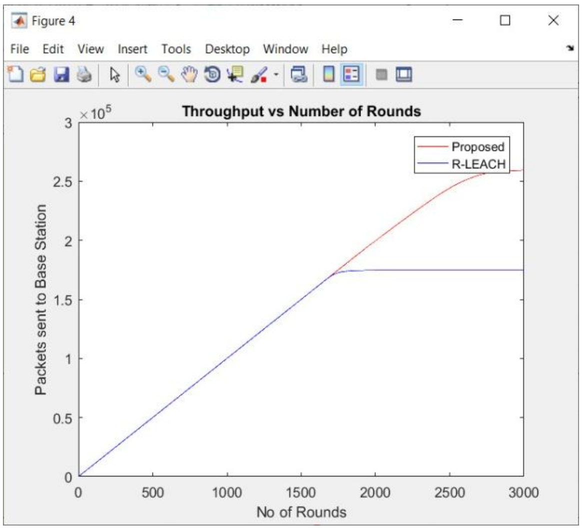

Figure 3: Comparison of Throughput against number of rounds

This graph shows the throughput of the network under both the schemes. The proposed scheme has higher value of throughput since the network was live for more number of rounds, so more number of packets were transmitted to the base station. The number of packets sent to base station was 259435 with the proposed scheme. With the Existing scheme, throughput is 174727 which means total no. of packets received by base station is174727 when network was simulated for existing scheme. Basically, nodes are getting dead lately in proposed scheme due to which more packets are received by base station.

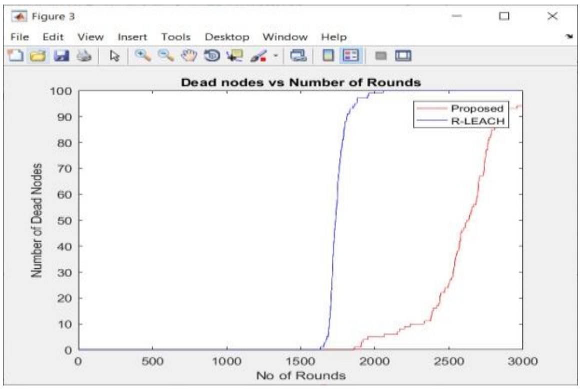

Fig 4: Comparison of Number of dead nodes against number of rounds

This graph shows the number of nodes dead in the network against number of rounds for both the schemes. The first node of network under the existing scheme got dead at the end of 1633 round and last node got dead at the end of 2056 round. whereas with the proposed scheme, The first node of network got dead at the end of 1861 round. In the proposed scheme 6 nodes are alive after simulation of 3000 rounds that indicates network is not fully dead.

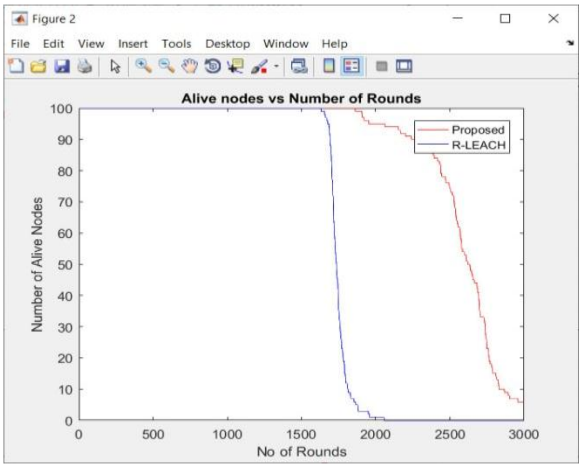

Figure 5: Comparison of Number of Alive nodes against number of rounds

This graph shows the number of nodes alive in the network against number of rounds for both the schemes. This indicates better network lifetime. Cluster head selection in the proposed scheme is based on firefly algorithm in which fitness function of the node is computed depending upon energy and distance of the node with respect to base station. Therefore , performance in the proposed scheme is better than existing scheme.

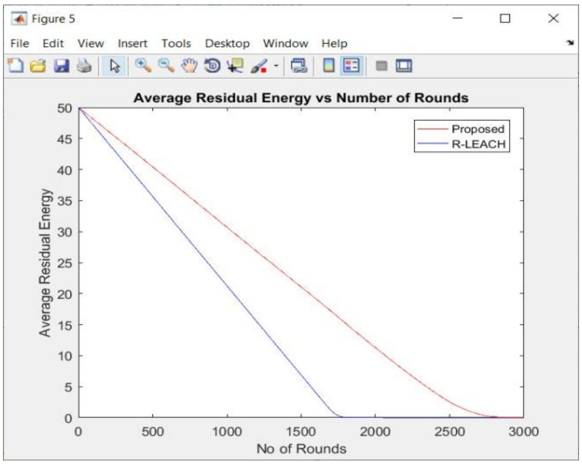

Figure 6: Comparison of Average Residual Energy against number of rounds

Average Residual Energy: Packet transmission to base station is done using multi hop communication. Firefly optimization is also applied in this phase in order to achieve better performance and minimizing energy usage.

V.CONCLUSION

In this paper, a novel firefly-based clustering method for selecting Cluster Head in WSNs was suggested. The user must supply probability for use with a threshold function in the LEACH method to evaluated if a node will acquired a

CH or not, resulting in an NP issue. The best fireflies selected using tournament selection are allowed to adopt among themselves via crossover and mutation in the suggested hybrid firefly algorithm. The suggested strategy allows for faster convergence while also avoiding several local optima. The suggested approach's efficiency in reducing packet loss rate is demonstrated by simulation outcomes. The proposed hybrid firefly method also extended the network's lifespan. Future work could be carried out to investigate the impact on increasing specific quality of service parameter.

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