A NOVEL APPROACH FOR ENERGY-EFFICIENT CLUSTERING TO MAXIMIZE THE LIFESPAN OF WIRELESS SENSOR NETWORK

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ABSTRACT
In the recent era, border monitoring, home security, and other IoT-based application design are based on wireless sensor networks (WSNs). However, the Sensor nodes (SNs) in isolated or remote areas cannot change their batteries because of their wireless nature. To extend the network lifetime of WSN, the most popular metaheuristic techniques ensure both CH selection and data transport. This article presents a strategy for enhancing the life of WSNs by choosing the optimum cluster head. Simulation results demonstrate that the propound scheme has improved the alive node, average network lifetime, packet forward to BS, and minimized dead-node of a network as contrasted with the existing MOD-LEACH and SEP protocols.

Keywords: *Clustering, Cluster Head, Wireless Sensor Networks, Network lifetime, LEACH*

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INTRODUCTION
WSNs are networks of a few hundred to a few thousand tiny SN that work together to do various tasks, such as target area observation, environmental monitoring, and many more. Additionally, WSNs have a wide range of applications, including those in agriculture, the military, healthcare, and more [1]. In a WSN, the SN is in charge of gathering and preserving the potential information necessary to reach the required decision-making processes, which the sink node must successfully and efficiently run. For efficient data collection and event monitoring, the SN should be distributed evenly or as needed. However, due to the non-rechargeable properties of dead batteries and the small number of accessible ones for efficient data collection and event monitoring, in this case, the SN must be distributed evenly or as needed. However, the deployed SN limited memory size range, small-scale computational potentiality, and non-rechargeable properties of dead batteries constrain their ability to carry out their intended activities [2]. Furthermore, the SN are designed to operate in hazardous environments; hence their batteries are permanently placed. SN play a key role in carrying out three crucial tasks, including data sensing, dispensation, and relaying, which consume a significant amount of energy to provide the choice of sending the aggregated data to the base station (BS) [3]. One popular strategy for saving the energy of SNs is energy-efficient routing. Clustering is an efficient technique that addresses the significant difficulty of energy conservation in this context [4]. In WSNs, the clustering process helps organize the SN into various groups known as clusters. The current focus is the two rational dimensions of sink mobility and CH selection.

Additionally, the clusters are motivated to use a multi-hop communication technique to reduce the energy usage of SN due to the subsequent issue that results from an increase in the network area. As a result of the clusters being heavily weighed down by traffic information, the hotspot problem is introduced by adopting a multi-hop communication approach [5]. The sink eventually loses network connectivity as a result of the hotspot issue. The capacity to regulate network load and frugally increase the likelihood of sending the energy across the sink makes the mobility of the sink more promising in resolving the hotspot issue. Carriers of the mobile sink may be related to a public transportation system that uses a pre-established for managing CH selection and using sink mobility to optimize data transmission throughout the network's SN. However, most of the currently published efforts in the literature either focus on sink mobility or CH selection, but not both. Only a few studies that concurrently focused on sink mobility and CH selection and added to the literature using hybrid methodologies were found. Figure 1 depicts the communication in WSN. The primary motivation for using a mixed strategy is to gain the impressive advantages of both optimization techniques to achieve the best network performance.

Additionally, the swarm intelligent met heuristic algorithms, which predominantly handle the process of exploitation and exploration, can be used to optimize the CH selection and sink mobility [6].

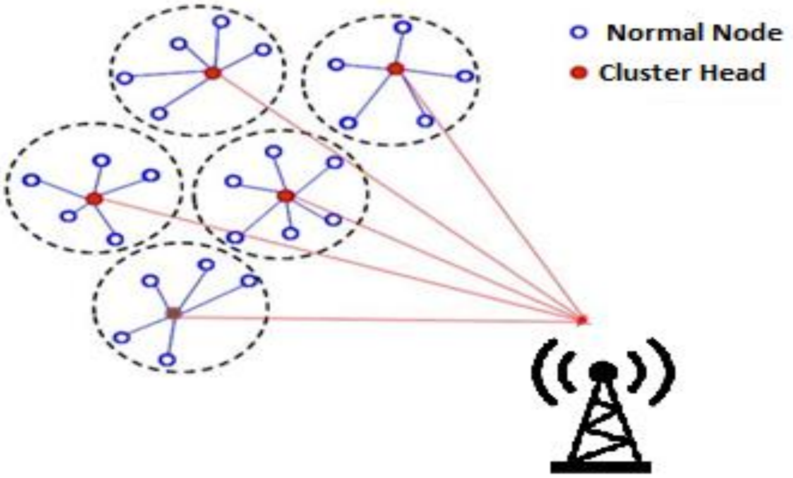

Figure 1: Communication in WSNs

1.2 Research Contribution

To increase the lifetime of WSNs, this study proposed the energy enhance protocol. What follows is a list of specific contributions made in this paper, and the following are some of the advantages of the proposed protocol.

a) The goal of the proposed protocol is to balance the load such that each SN has an equal chance of acting as a CH.

b) To determine which nodes are most suited to play the CH job based on rank.

c) For cluster formation, there is a choice of nodes that aren't CHs when they're deciding to join a cluster.

d) Unlike proposed protocol, which prioritizes BSs located in the centre and distance from the playing field, proposed protocol gives more weight to BSs situated near the field's corner.

e) The proposed protocol is simulated and contrasted with MOD-LEACH [16], and SEP [17] protocol.

f) The efficacy of proposed protocol is assessed using simulation experiments and the findings are compared with a good traditional protocol such as the MOD-LEACH [16], and SEP [17] protocol.

The rest of the article structure are as follows, in section 2 discussed related work, System models discussed in section 3 , proposed protocol explain in section 4 with its different phases. The simulation test and result examination are also discussed in section 5, and finally a conclusion and future work explain in section 6 in this research article.

1. LITERATURE REVIEW

LEACH [7] is a fully distributed method. In the setup step, CHs are chosen, cluster formation is carried out, and TDMA preparation is finished. The cluster head assembles information that nodes provide them in a steady state after that data is transmitted to the BS. A predetermined round period is followed by clustering. All member nodes are given the CH position to maintain a balanced network load. When using the LEACH theme, there may not be an equal number of collections of CH in each cluster. In a network with unequal cluster sizes, Data transfer between CHs via multi-hop channels is governed by the centralized law [8]. For CH selection, EAP[9] offers new parameters which can manage various power nodes. To determine the residual power of every node in cluster, each node keeps a table of the remaining energy of nearby regions. The residual power node has several CH possibilities to choose the remaining central power. There are two tiers in the DEEC [10] network. Front nodes and common regions are the two categories of SN. Compared to conventional nodes, advanced nodes are more powerful. The starting energy and remaining energy are considered to choose the collection's head. Super nodes, advanced nodes, and regular nodes all experienced greater node diversity due to EEHC (KUMAR e colab 2009). There are no schemes that have a predetermined choice of group header that is designed to reduce internal group connections. This study has established a concept for choosing uncomplicated, inexpensive head collections that boost network time while reducing network connectivity. In Z-SEP[12], the networks' heterogeneity was increased compared to LEACH. In Z-SEP, specific high-energy nodes are referred to as advanced nodes, and CHs are more likely to be found in advanced nodes rather than non-advanced ones. Only advanced nodes receive the maximum CH selection under this procedure, which results in an uneven distribution of CHs. The less advanced normal node dies first cluster head nodes are not randomly chosen for the EE-LEACH [7] protocol. The two elements used to calculate CH are the residual energy and connection cost of the SN, which are naturally clustered. The three steps of the operation are initiation, repeat, and finalization. Energy is considered the most crucial factor when selecting a SNs to serve as a CH. This protocol uses inter-cluster communication techniques for data delivery to conserve as much network energy as possible. EE-LEACH forms clusters by performing the most iteration possible while using the most network energy. Hot spot issues could result from some CHs being close to the BS.

2. SYSTEM MODEL

In the network model, there are two places where the position of the BS is fixed. There is no hole in the network, and the network is fully utilized. If there is a networking hole, the SN and the BS link will break. Due to this, it will not be possible for the SNs to collect the message from one place and send it to the BS.

3.1 Energy Model

All nodes of SN are planted in the random mode because their positions are not planned. The distance between the two nodes in sensor networks determines how much energy is lost during contact. A model of radio energy dissipation is shown in Figure 2. Both the transmitting and receiving phases of data transmission consume resources. The increasing energy a node uses to transmit k-bits of data across an aloofness d is computed using equation no. 1 following the energy model proposed in[14][15]. The energy of the network may be depleted in sensing, aggregation, amplification, transmission and reception. Energy dissipations during transmitting (E_{Tx}) and receiving (E_{Rx}) k bits over d distance are given by equation 2.

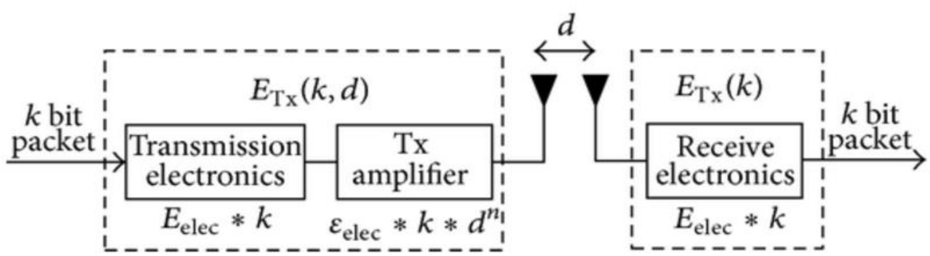

Figure 2: Radio energy dissipation model

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d) \quad (1)$$

$$E_{Tx}(k,d) = \begin{cases} k \times E_{elec} + (k \times E_{fs} \times d^2) & d < d_0 \\ k \times E_{elec} + (k \times E_{amp} \times d^4) & d \geq d_0 \end{cases} \quad (2)$$

$$E_{Rx}(k) = k \times E(elec) \quad (3)$$

E_{elec} , $\mathcal{E}_{fs}$ and $\mathcal{E}_{amp}$ is the energy exhausted in electrical components, energy dissipated in free space and energy dissipated in multipath, respectively. Energy utilization for receiving that k-bit message is given by equation 3.

3. PROPOSED WORK

The homogenous network employs the suggested protocol. Each node has the same sensing, processing, and other capabilities in a homogeneous network. In contrast to the MOD-LEACH [16], and SEP [17] protocols, where the load balancing of a chosen cluster is not constant, all SNs in the propound protocol have the same energy to elect the CH. aloofness between CH and BS is crucial since communication requires a lot of energy. The propound protocol tries to get around these restrictions and uses load balancing to extend the stability period. The network model is discussed to recognize better how the planned work will function before we start.

4.1 Network Model

Before a wireless sensor network can start functioning, its network representation must be established.

a) All the SN is the same and has the same amount of energy.

b) RSSI (received signal strength index) is used to compute aloofness between two devices.

c) No movement is detected in BS or SN.

d) All interactions inside the network are mutual.

e) If a node's battery level reaches 0, it is presumed dead.

f) SN is powered by a battery that cannot replace or recharged.

g) The entire region of interest in the propound technique is 100x100 $m^{2,}$ with SN randomly distributed throughout. The location of BS is 50 × 50 m^2 and 150 ×50 m^2.

4.2 Clustering Process

The operation of propound protocol is divided into three phases; all these phases make an effective routing technique from source to destination

a) The phase of the CH election

b) A stage of Cluster formation

c) The phase of Data dissemination

4.2.1 Phase of the CH Election

To extend the lifetime of WSN, the CH election step is crucial. A packet (LOCAT-BS) includes the location of the BS, and BS transmits the TDMA protocol after all setup is complete. All SN are initially alive. They gather all relevant data from the arranged area in their region and transmit (INFO PKT) inside its radio range by the schedule for receiving a signal from BS. After broadcasting, the message SNs computes residual energy, average distance to the member node, distance from BS, and centrality. All information is put in equation no. 4, and the calculation of the Rank of each node is also performed.

$$\text{Rank (R)} = \frac{MN(i).ENERGY \times MN(i).Centrality}{MN(i).AVD\_MN \times MN(i).Dis\_BS} \qquad (4)$$

According to the schedule, each node advertises its candidacy within radio range. For example, suppose a node has the highest Rank after completing all levels. In that case, it will either wait to join an ideal cluster, advertise its candidacy, or communicate information about its surroundings, average distance, and battery state to other nodes. Algorithm 1 discusses the CH election algorithm.

	Algorithm 1: Selection of Cluster Head of Propound Protocol
	Begin
1.	Numbers of Node =N
2.	Total Area =100× 100 m^2
3.	Rank=R
4.	Preliminary Battery stage = MN_ENERGY
5.	Member Node = MN_Type
6.	Initially node Rank = 0
7.	Member Node Average Distance = MN_AVD_MN
8.	Calculate centrality with radio range = MN_Centrality
9.	No of CH formation = 0
10.	Distance between SN to BS = MN_Dis_BS
11.	Calculate Rank by the equation no 4.
12.	Every node announces its Rank and CH candidacy within radio range
13.	**For** (i = 1 to p%)
14.	**if** MN(i)_R > Rec _Tn(i)_R Then

15.	CH = MN(i)_Type
16.	Count CH^{++}
17.	Add MN(i) to list of CH
18.	Broadcast (HEAD_NODE) packet to its surrounding
19.	**End if**
20	**End for**
	Terminated

4.2.2 Phase of Cluster Formation

SN is the only p% that has a part in CH. If 100 nodes are deployed, only 10 of them will serve as CH; if 200 SN are deployed, only 20 CH will serve as CH. Every NON-CH node, aside from the CH node, must decide whether to join the cluster. Some features include the density around NON-CH nodes, residual energy, and separation from the CH node, and the typical distance to member nodes from NON-CH. Given all this critical information, the equation will be used to determine their chance (5).

$$\text{Chance (c)} = \frac{CHN(i).E}{Dist\_to\_CH\ N(i) \times CH\ N(i).AVD\_MN} \quad (5)$$

After computing all CH nodes' probability, the NON-CH node will select the CH node with the highest chance and send a packet (CL_JOIN) to that CH node. When the request is authorized, the CH node will send an acknowledgment (ACCEPT ACK _JOIN) and a TDMA schedule to the requesting node. This method is used to create all of the clusters.

4.2.3 Phase of Data Dissemination

After cluster formation and CH assortment, the data transmission stage begins. First, all sensed data is transmitted by a member node of a certain cluster from the target area to their respective CH. to reduce collisions per TDMA slot. Then, CH aggregates the data to the associated BS after applying data fusion to the information [13]. Thus, one round is finished.

4. SIMULATION AND EXPERIMENTAL RESULT

The simulation outcome for the suggested technique is superior to that of MOD-LEACH [16] and SEP [17]. MATLAB has been used exclusively to execute the simulation. The network's size is calculated to be 100 ×100 m^2. The essence of SN lies in its stability. The experiment is carried out to ascertain normalization-related factors. The best CH percentile is measured to be 10% of an SN (P percentile). This protocol computes several matrices, such as the number of alive nodes every round, the network's energy level, packet transmission to the BS, and the number of dead nodes in WSNs. Two distinct scenarios are taken into consideration in this technique.

Table 1: Network Parameter

Parameters	*Values for Scenario1*	*Values for Scenario2*
Total SN	100	200
ε_{fs}	10pJ/bit/m^2	10pJ/bit/m^2
ε_{amp}	0.0013pJ/bit/m^4	0.0013pJ/bit/m^4
E_o	0.5J and	1J
Data packet	3000 bits	4000 bits
E_{DA}	5nJ/bit/report	5nJ/bit/report
E_{elec}	50nJ/bit	50nJ/bit
E_{TX}	50nJ	50nJ
E_{RX}	50 nJ	50 nJ
BS Position	(50,50)	(150,50)

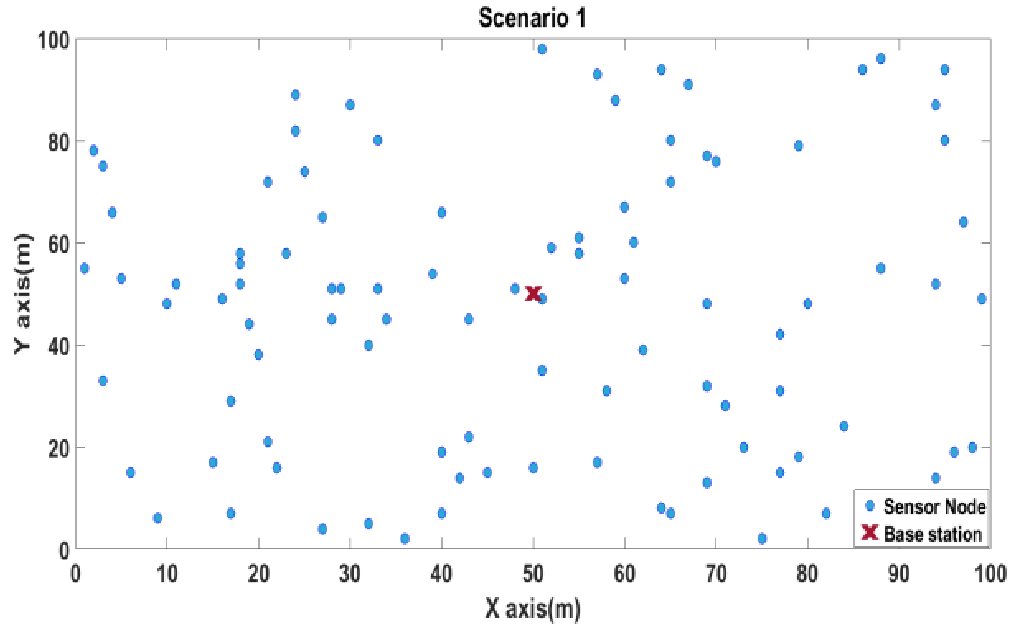

Figure 3(a): Network Layout Scenario 1

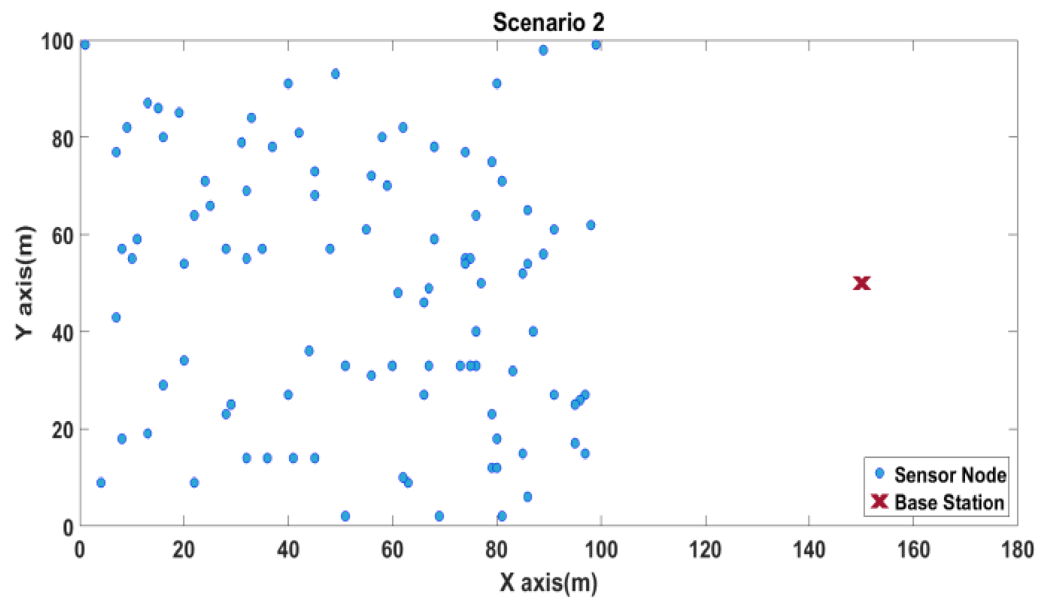

Figure 3(b): Network Layout Scenario 2

5.1 Alive Node Per Round

To calculate the alive node for WSN, use equation 9 to compute the live node per round. We can see that for scenario 1, the proposed protocol has shown improvement of 60.71% and 22.44% over MOD-LEACH and SEP protocols, respectively. Similar improvements can be observed for scenario 2: 169% and 30.76%, respectively. The best candidates for the CH position were selected as a result of the characteristics taken into account during the CH selection process, which is why the suggested protocol performed better in terms of surviving nodes. Additionally, it cycled the work and balanced the network load.

$$M_X^i = F_{Res}^i(m) > 0 \quad (9)$$

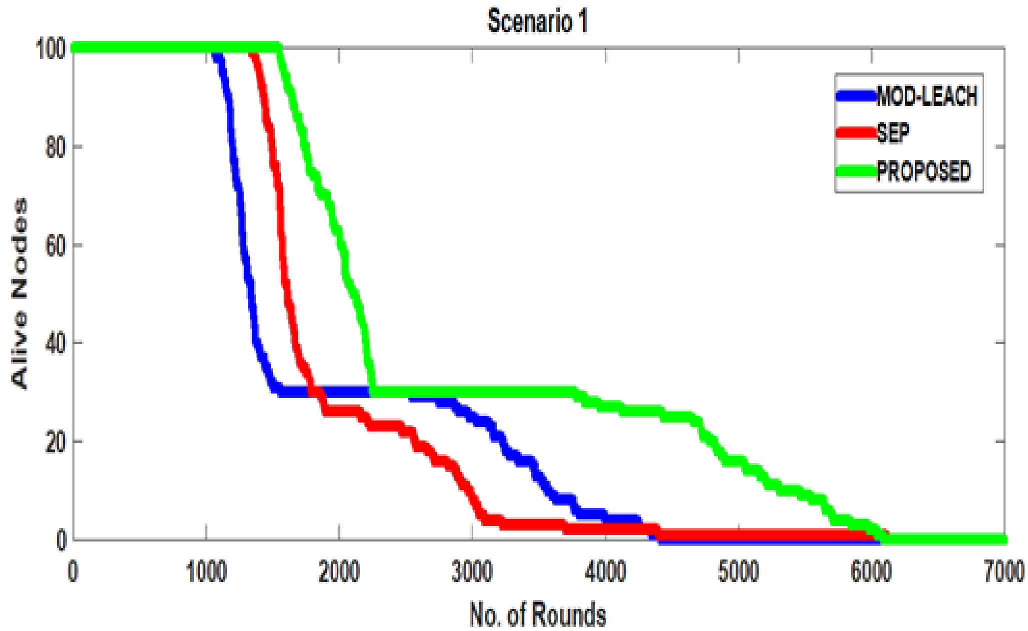

Figure 4(a): Alive node for WSN

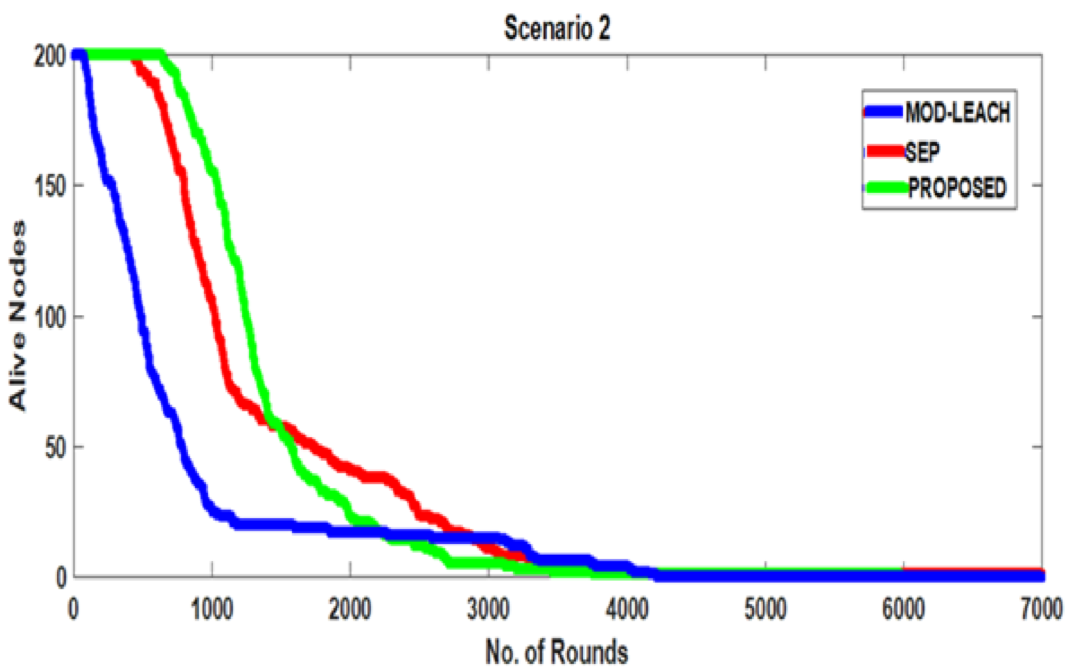

Figure 4(b): Alive node for WSN

5.2 Dead Node Per Round

Inactive nodes of the network affect the lifetime of the WSN. Figure 5 (a–b) shows the network lifetime for the two scenarios that were taken into account throughout the simulation. Compared to MOD-LEACH and SEP protocols, the suggested protocol has better performance considering the death rate of nodes in each round in the position AOIs.

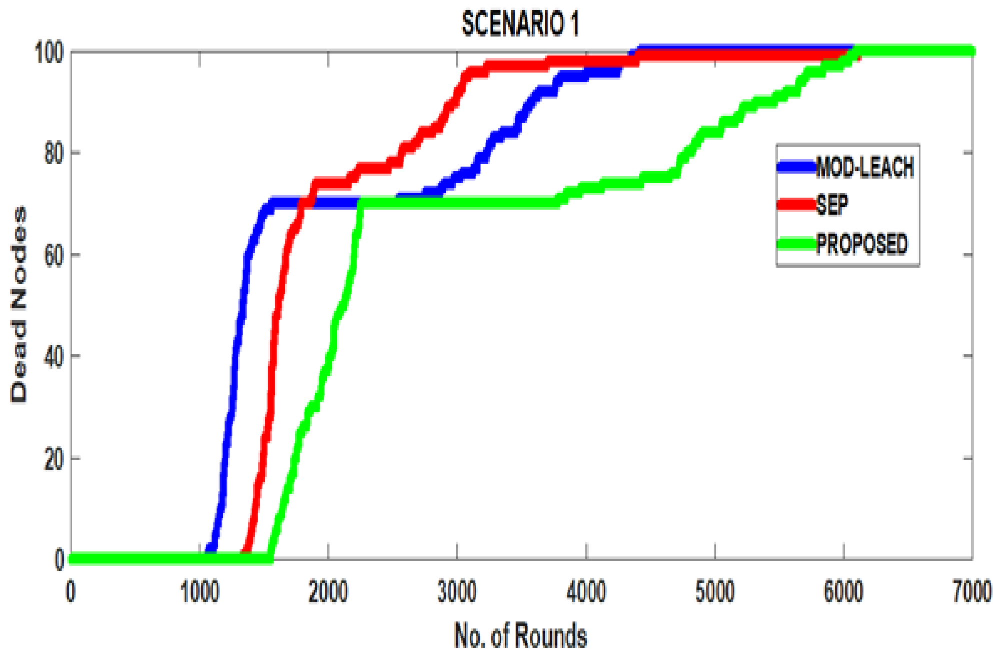

Figure 5(a): Dead node for WSN

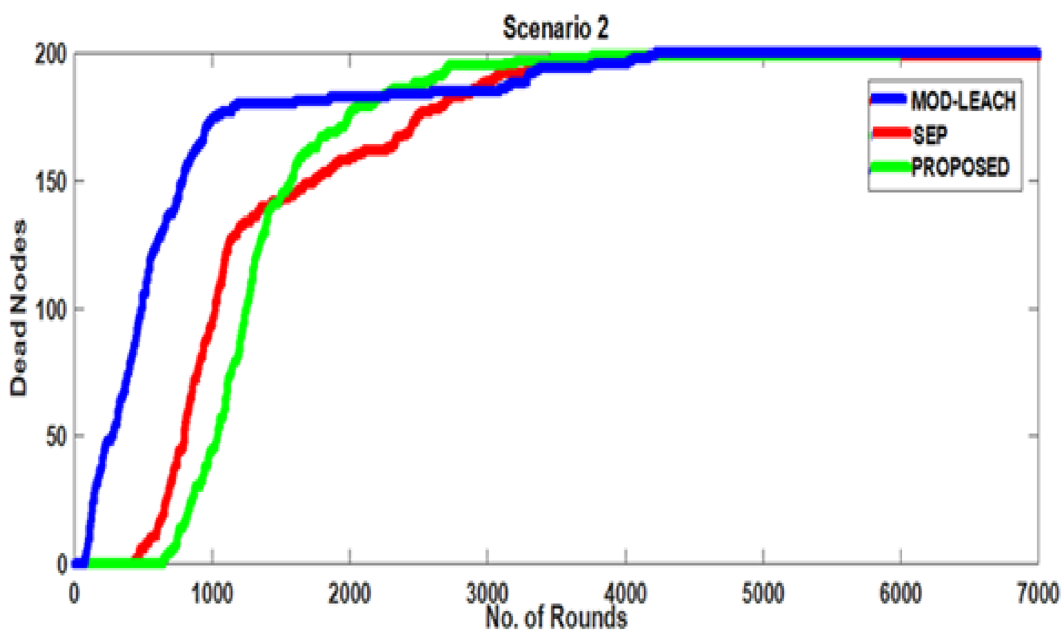

Figure 5(b): Dead node for WSN

5.3 Packets Send to BS

The maximum packet obtained by the BS indicates that the network has experienced numerous growth rounds. Figures 6(a) & 6 (b) demonstrate the highest packet forward to BS through CH. The proposed protocol outperforms MOD-LEACH and SEP regarding the packet transmission rate. Furthermore, more packets are transmitted with reduced energy usage by allocating more duty cycles to nodes closer to one other. As a result, there is a minimum energy usage for transmission per packet, as seen in Figure 6 (a-b).

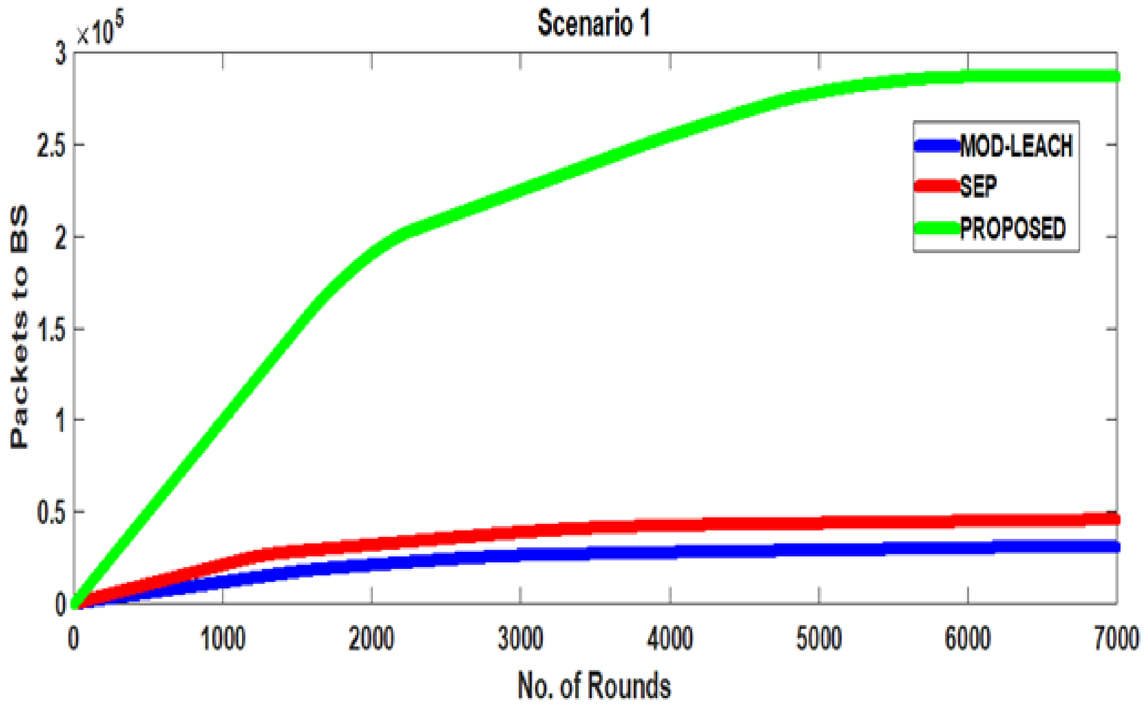

Figure 6(a): Forward packet to BS

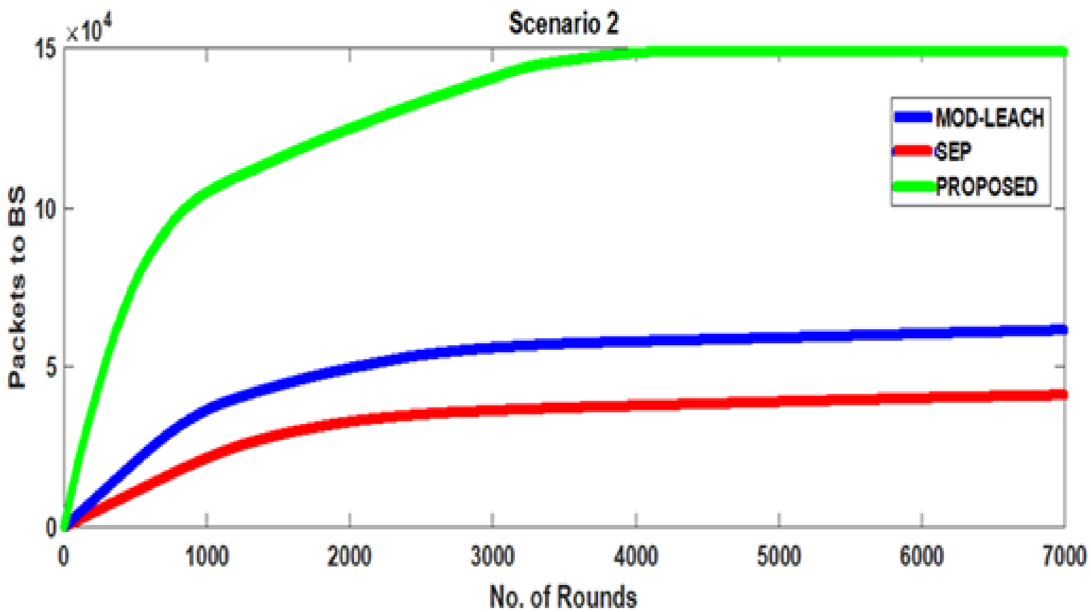

Figure 6(b): Forward packet to BS

5.4 Average energy of network

To extend the network's lifespan, there must be an equitable distribution of load across the nodes. Suppose nodes are dissipating energy similarly if the network's average energy is higher. Figure 7(a-b) shows the network's average energy for each scenario. The figure shows that the network's energy consumption rate is low and stable compared to MOD-LEACH and SEP protocol, regardless of whether the BS is close to the AOI or far away. The effective cluster construction and data routing cause improved performance.

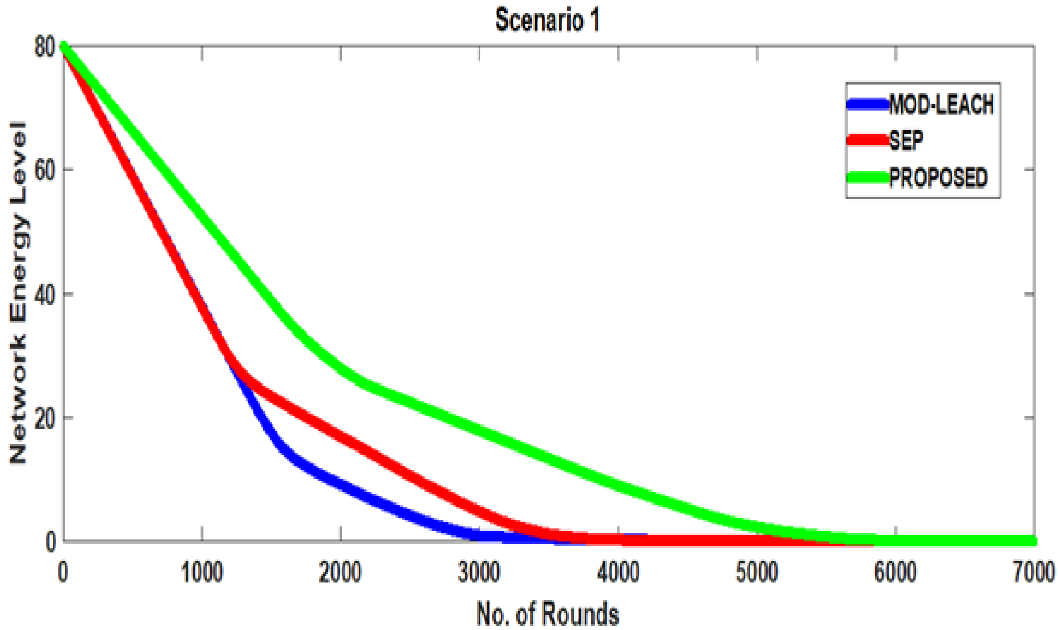

Figure 7(a): Average energy of network

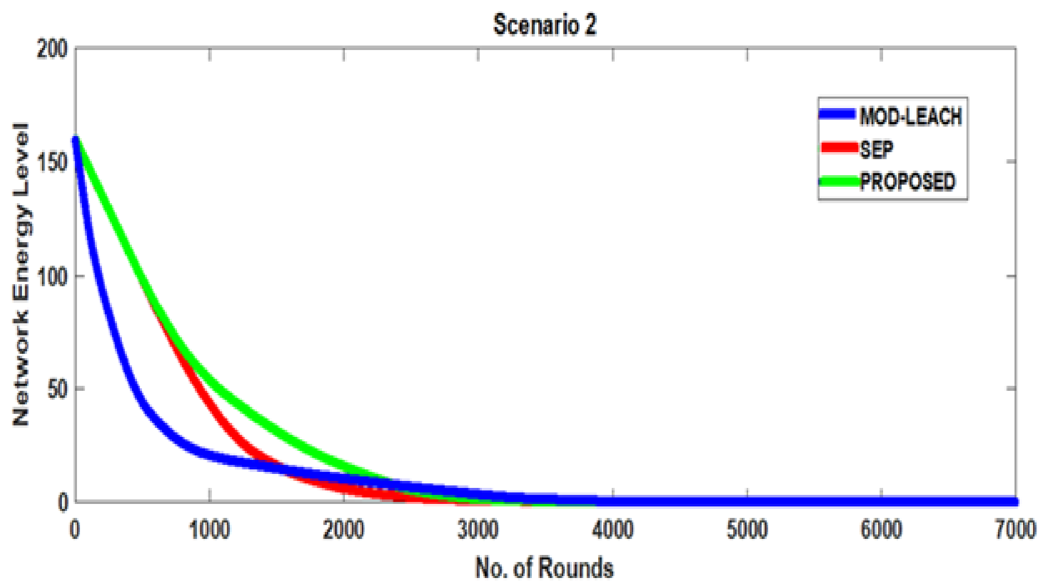

Figure 7(b): Average energy of network

5.5 Complexity Analysis of Proposed Protocol

Time Complexity

Currently, the network consists of n nodes. Therefore, an SN will do at most (n-1) rank comparisons to elect itself as CH. Because of this, the total number of comparisons for CH selection in a graph with n nodes is n (n-1). Each node that isn't a member of the CH will determine the likelihood of each node in the CH Node list, and then use that information to construct a cluster. Thus, there will be at most (n-1) comparisons. In the event of routing, there will be k comparisons made, given that there are k communication hubs. Because of this, the BIG-Oh complexity of the proposed protocol is O (n^2).

5. CONCLUSION

The energy limitation of SNs is one of several resource restrictions that affect WSNs. After the deployment of SNs, the SN starts to communicate; At this point, energy exhaustion begins, and all SNs cease to exist. The proposed protocol follows cluster formation, CH selection, and data dissemination. The selection of CH depends on the Rank, which is determined by several input variables, including node density, residual energy, and distance from BS. All non-CH nodes intelligently select their CHs during cluster formation by estimating the probability of each CH node. Simulation tests have been performed for two situations by varying the BS position. Based on the result, we can say that the proposed protocol is more efficient than the traditional protocol and enhances the lifetime of WSNs. In the future, we will apply the optimization algorithms (e,g BBO, Ant Colony etc.) for WSN to get the best result in terms of energy efficiency, and also we will consider mobile SNs which is more helpful in IoT application.

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