

An Energy efficient LEACH protocol and optimal relay selection in Wireless Sensor networks

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Abstract

The power supplies of wireless sensor networks for nodes haven't been rechargeable because of environmental factors. It makes the challenge for WSNs to achieve the energy efficiency and prolong the lifetime of a network. Most of the sensor energy consumes by the data transmission in WSNs that affects the network lifetime. To reduce the communication protocols' impact on the overall consumption of energy in a network, different types of mechanisms have been proposed. After partitioning a network into clusters with the use of low-energy adaptive clustering hierarchy (LEACH), some nodes have been selected as cluster head (CHs) randomly and CH role is rotated among nodes for even distribution of energy load across the network. A novel modified routing protocol is proposed in this paper for improvement of energy efficiency in WSNs. This new improved energy adjusted LEACH (EA-LEACH) protocol has been considered the nodes' residual energy and their average energies. To get the decreased consumption of energy among sensor nodes, EA-LEACH protocol doesn't involve the nodes in the formation of a cluster when they are nearer to the BS (Base Station) and considers the optimal CHs. Accordingly, the improved delay PSO (DPSO) is used in the data transmission phase to be selected the efficient relay node based on the consideration of node cost and end-to-end delay for sustaining the energy efficiency across the network. The simulation results are analyzed and proved that the better performance in energy efficiency, network lifetime, and communication quality with the proposed method.

Keywords: EA-LEACH, DPSO, PSO, Cluster head selection, LEACH, WSN.

I. Introduction

The combination of numerous sensor nodes is formed a wireless sensor network (WSN) that collects a required data from locations, where humans are always not able to retrieve the data [1]. In military areas, the wireless sensor networks have been deployed as the sensed data is played a crucial role in the total military operations. In all of the data processing operations across the network, the energy is considered as a vital parameter as the network is wireless [2]. Different types of protocols have been introduced based on the energy consumption.

To achieve the energy efficiency of a network and easier management, one of the efficient techniques is used as LEACH (Low-Energy Adaptive Clustering Hierarchy) that makes the partitioning of a network into clusters [3]. Two different phases are involved in this protocol, such as i) Setup phase; and ii) Steady phase. Based on the default value of threshold, the nodes select as cluster-heads in the first phase. The below equation is used to determine the threshold:

$$r(n) = \begin{cases} \overline{1 - P[(r \bmod TH(n))]} & \text{if } n \in G \\ 0 & \text{otherwise} \end{cases}$$

Where, P refers to the probability value and TH (n) represents the n nodes' threshold value. The random number from 0 to 1 is chosen by each node of a network. Then, the chosen value compares with the obtained value of threshold. Then the node will act as a cluster head (CH) if the threshold value is greater than the chosen value or else the node will be acted as member nodes. In each round of CH selection, the process is carried out. The sensed data send to the CH using member nodes for data aggregation once the CH is elected. Then, the aggregated data send to the BS by the CHs [4]. The clustered WSN's network topology is showed in the below Figure 1.

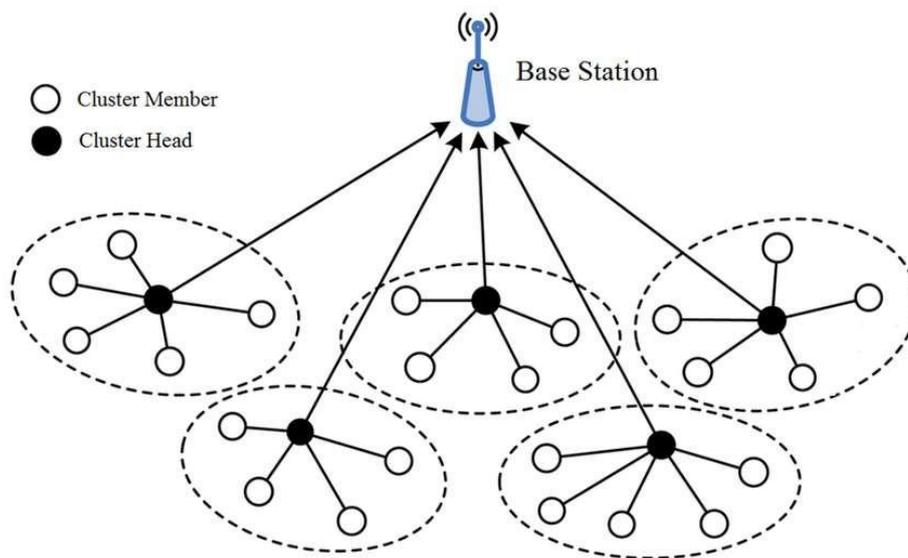


Fig1: Network topology of a clustered WSN

Until the completion of scheduled time, this process is continued. Then, the setup phase is processing for next round of CH election [5]. For management of nodes' energy level, the previous round of node that acted as CH wouldn't be served as CH for next round to prolong the cluster lifetime and network scalability [6]. A single-hop routing format is also followed by the LEACH protocol, in which communication of each node is connected with CH and perform the data transmission towards the SINK that makes the non-suitability of an application for larger regions. For each round, CH election is performed and advertising the same CH that consumes more energy in a network. The main research trend is that the developments are required for energy consumption issue in the dynamic clustering [7].

Advantages and Disadvantages of Traditional LEACH

LEACH protocol includes a range of benefits, such as:

- The overall data aggregation is performed by the cluster heads that results in the traffic reduction of a network

- Energy will be saved since single hop routing is there from node to cluster head
- As LEACH doesn't require any control data from the BS and global knowledge about the network, it is completely distributed.

Some of the drawbacks of LEACH are included as follows:

- The distribution of cluster heads and their optimal number can't be assured with the LEACH protocol.
- The lower residual energy of a node may cause under earlier death due to the same priorities given to the nodes with lower and higher residual energies to become the cluster heads.

Major Contributions of the Paper

- Four different parameters, like average energy and total energy of a network, nodes' residual energy, and initial energy have been introduced in the threshold setting of the proposed technique.
- The node that is nearest to the BS doesn't involve in the formation of a cluster than the CH in this proposed protocol of EA-LEACH.
- To make the efficient relay node selection, the delay based PSO (DPSO) has been used to reduce and balance the sensor nodes' energy consumption. It considers the cost and end-to-end delay to choose the relay node efficiently.
- The proposed approach has included the main benefit is that the network lifetime extension, enhances the energy efficiency, throughput, scalability, and link quality.

Energy Usage Model

To define the performance of a system, the energy consumption is played a key role in WSNs. The schemes that used in a network are considered to decrease the consumption of energy for achieving the prolonged network lifetime [8]. The energy usage model of a WSN is showed in the below Figure 2.

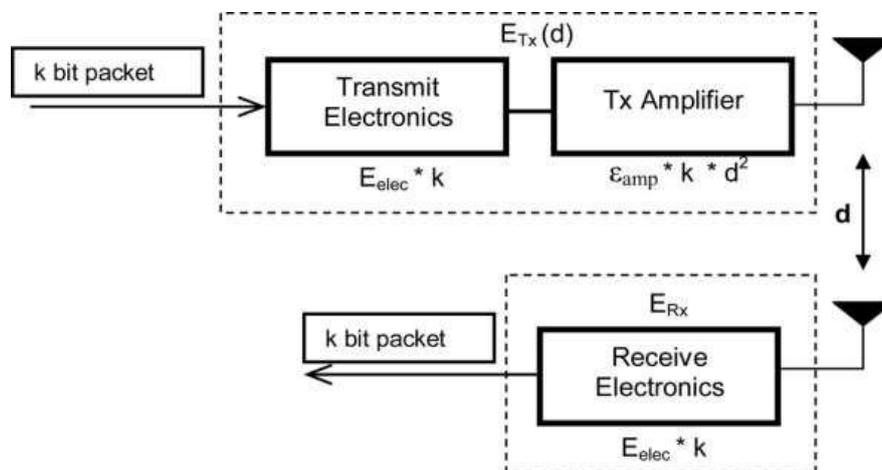


Fig2:energyusagemodel in WSN

The above-mentioned energy model is used to evaluate the consumed energy for data transmission and reception while using the radio signal for data communication between nodes in WSNs [9]. Two different channels of the energy model are included multi-path fading channel and free space channel. The free space channel uses if the lower distance (d) exists between sender and receiver compared to the threshold d_0 . Below-equation shows the required energy using the model for sending a k -bit message over the distance d .

$$(,) = \begin{cases} kE_{elec} + k\epsilon_{fs}d^2, & d \leq d_0 \\ + k\epsilon_{mp} d^4, & d \geq d_0 \end{cases}$$

Where, E_{elec} refers to the energy that requires for electronic circuit, d_0 represents the threshold, ϵ_{mp} is the required energy by multi-path channel, and ϵ_{fs} refers to the required energy by using the free space. For k -bit data reception, the required energy is given as follows:

$$() =$$

An electronic circuit (E_{elec}) consumes the energy that relied on different factors, like the signal filtering, spreading, modulation, and digital coding, etc. By relying on the distance between sender and receiver, and bit error rate, the energy is consumed by the amplifier of multi-path ($\epsilon_{mp} * d^4$) or free space ($\epsilon_{fs} * d^2$).

II. Literature Survey

The learning automata-based multilevel heterogeneous routing (LA-MHR) has proposed for CHs' selection using the S-model based learning automata [10]. In this protocol, the cognitive radio spectrum is allocated by the BS and a multi-hop communication is used instead of a single-hop communication for sensor nodes. Because, this scheme requires huge amount of transmission power that doesn't provide by the single-hop communication.

At multiple nodes of a network, the LEACH-Mobile (LEACH-M) protocol was proposed to enhance the success rate of data transmission. As similar as the LEACH, the selection of a cluster head after forming the clusters is carried out in the LEACH-M. Compared to the LEACH, more energy is consumed by LEACH-M due to the higher control overheads.

Fouzi et al., [12] have proposed the energy-efficient cross-layer protocol (EECP) to bring the interactions between different layers of data transmission, such as physical layer, network layer, and MAC layer for WSNs. EECP could be created the neighboring tables that will helpful in awakening of qualified nodes to transmit the data. A wake-up mechanism is applied at the MAC layer to overcome the issue of overhearing.

Sing et al., [13] have improved the energy-efficient cross-layer protocol using the adaptive threshold routing for WSNs. For executing the protocol, different steps are performed, such as CH selection, deployment, initialization, sending of an aggregated data to the BS, and cluster creation.

Sarvi et al., [14] have presented a new adaptive cross-layer (NAC) error control protocol to achieve the reliable multimedia communication with increased energy efficiency for WSNs.

At the application layer, the adaptive cross-layer erasure coding is incorporated that would be useful in determining the redundancy for the wireless link layer based on a dynamic hybrid FEC/ARQ scheme. To implement this proposed protocol, the unequal error protection (UEP) and retransmission strategies without any delay constraints are considered to optimize the energy and distortion.

III. Proposed Method

LEACH Protocol

In the WSNs field, LEACH protocol is played a crucial role. From the member nodes, the collected data compress by using the CH of each cluster in the phase of CH election and sends to the SINK node. Based on the rand function and threshold value $T(n)$, the CH determines using the selection mechanism. A random number $M(0 \leq M < 1)$ is generated by the SN. The node becomes the cluster's head node in a current round when it is satisfied with the constraint of $M \leq T(n)$. The value of $T(n)$ estimates as follows:

$$T(n) = \begin{cases} \frac{1}{1 - P * [(r * \text{mod}(1/p))]} & \text{if } n \in G \\ 0, & \text{otherwise} \end{cases}$$

Where, $\text{mod}(\cdot)$ is the modules operator, p indicates the ratio of the total number of CHs to SNs and it is represented as each node's probability becoming CH during round 0, G refers to the set of nodes that haven't been selected like CHs in the round of $1/p$, and r indicates the current number of rounds.

The clustering concept and periodic data collection are adopted in the LEACH for reduction of data transmission between BS and the node. The energy loss can be reduced and network lifetime improves using this method. Additionally, the data aggregation method is used by CH to decrease the local correlated data. The method helps in minimizing the energy conservation and optimizing the data transmission over the network. LEACH uses the schedule of time division multiple access (TDMA) that makes allowing the member nodes into sleep mode while holding the collision back between clusters and improves the battery life of sensor nodes.

In the CH election, the nodes' density is not taken into account in the traditional protocol of LEACH. During the allocation of CHs, the nodes' location and placement and how many nodes are expected to be the number of CHs per round have been considered. That means, the uniform distribution of CHs couldn't be assured using this protocol. The LEACH protocol doesn't concern about the nodes' average energy and their residual energy in case of CH selection. It will be resulted that the lower energy node is being selected as CH. It makes the quick exhaustion of node energy. With the adoption of a single hop communication mode, the role of CH is communicated with the BS directly. When some CH nodes are far away from the BS, they consume almost 80% of the energy due to the longer distance data transmission. If $d \approx 141$ m, the ratio between energy consumption of power amplifier and the total energy consumption is 80% for the free space channel model. Whereas in the multipath

fading channel, this ratio is about 80% if $d \approx 112m$. It's required to improve the energy-efficient protocol for real-time application for reducing the WSN's energy loss.

ClusterHead SelectionAlgorithmof the EA-LEACH Protocol

LEACH protocol can't ensure that the optimized residual energy of CH even though there are many benefits provided by the protocol. The traditional LEACH-based protocols have been considered the threshold selection $T(n)$ based on the selection of nodes as CHs irrespective their residual energies. The random selection of CHs is performed. The nodes will be died quickly when a node that has lower energy is selected as CH. A new threshold $T(S_i)$ was proposed to be achieved the balanced energy utilization and increased network lifetime. It defines as follows:

$$T(S_i) = \begin{cases} \frac{E_i}{E_a} \cdot \frac{1}{1 - p_i(r \bmod N)} & S_i \in C \\ 0 & otherwise \end{cases}$$

Where, S_i refers to the node and $i \in [1, N]$. The parameter of energy adjustment p_i is expressed as follows:

$$p_i = \frac{E_i \cdot E_a \cdot E_t}{E_i^2 \cdot E_t}$$

Where, E_a refers to the sensor nodes' average energy of a WSN, E_i indicates the i th node's initial energy, E_t indicates the total energy over a network, E^i represents the i th node's current residual energy, and p refers to the proportion of optimal CH selection. As shown in the equation, initial energy, average energy, and residual energy of sensor nodes, and total energy of a network are used to determine the parameter of energy adjustment. The improvement can be ensured that every node is died at the same time approximately. It makes balancing the distribution of energy load among nodes using the proposed method and the network lifetime prolongs. The probability of choosing the nodes as CHs can be increased with the improved value of $T(S_i)$ when more residual energy of nodes is included than E_a . It is obtained after operating for r rounds using EA-LEACH as follows:

$$T(S_i) = \frac{E_i(1 - \frac{r}{N})}{E_a}$$

When start processing the CH selection, the nodes have been distributed in the WSN randomly. By comparing with $T(S_i)$, each node produces the random number. If in case the obtained result is much lower or equivalent to $T(S_i)$, the node will be chosen as CH.

With the implementation of a proposed algorithm, the probability of becoming a CH would be increased for a node that consists of higher residual energy in comparison to the other remaining nodes. During the process of CH election, different energies have been included in all nodes under the approach of EA-LEACH. In this method, the network can have included that each node is died at the same time approximately as it selects the nodes as CHs only

when they have more residual energy instead of the lower residual energy of nodes. Thus, the network lifetime can be enhanced using the EA-LEACH protocol.

The other nodes' data about the becoming the CHs in the round will be informed by the CHs after completing the CHs' election. To accomplish this, a non-persistent carrier-sense multiple access (CSMA) MAC protocol is used to send the advertisement message by each CH node to all other nodes through the broadcasting process.

The participation of each member nodes in the formation of a cluster is relied on the transmitted message signal intensity from each CH to BS. The pure signal strength relates to the cluster head election as the proposed protocol of EA-LEACH uses the symmetric propagation channel model. The distance between member nodes or CH and the sink node will be lower if the received signal is stronger. In the cluster formation, the nodes that are nearer to the BS are not participated and the data is directly sent to the BS upon the comparison of nodes' distance to CHs and BS.

For example, consider the node A and cluster head B and the distance between these two is d_{AB} . In this case, the cluster head is selected in a network and broadcasts the messages to other nodes when the nearest cluster head B is determined by the non-cluster head node A. In any cluster, node A is not joined if the condition of $d_{AB} > d_{AtoBS}$ (d_{AtoBS} refers to the distance between node A and BS) is satisfied. It will communicate with the BS during data transmission. The node A joins with the cluster if $d_{AB} < d_{AtoBS}$. Here, cluster head B behaves as a cluster member node.

It's essential to make a note that all nodes are not being participated in the cluster formation of WSNs. The node is involved in the data transmission when it is closer to the CH, which transmits the strongest signals to the nodes. The decision of making including the nodes is done based on the comparison of all signal intensities of messages, which have been sent using the CHs.

Once determined the CHs that are closer to each node and which CH will be joined, the algorithm needs to inform about the CH that becomes the cluster's member node. The chosen CH receives a join-request messages that involves the identification of CH and node by each node that is nearer to the CH.

The proposed EA-LEACH protocol's cluster formation and CH selection process have been showed in the below Figure 3.

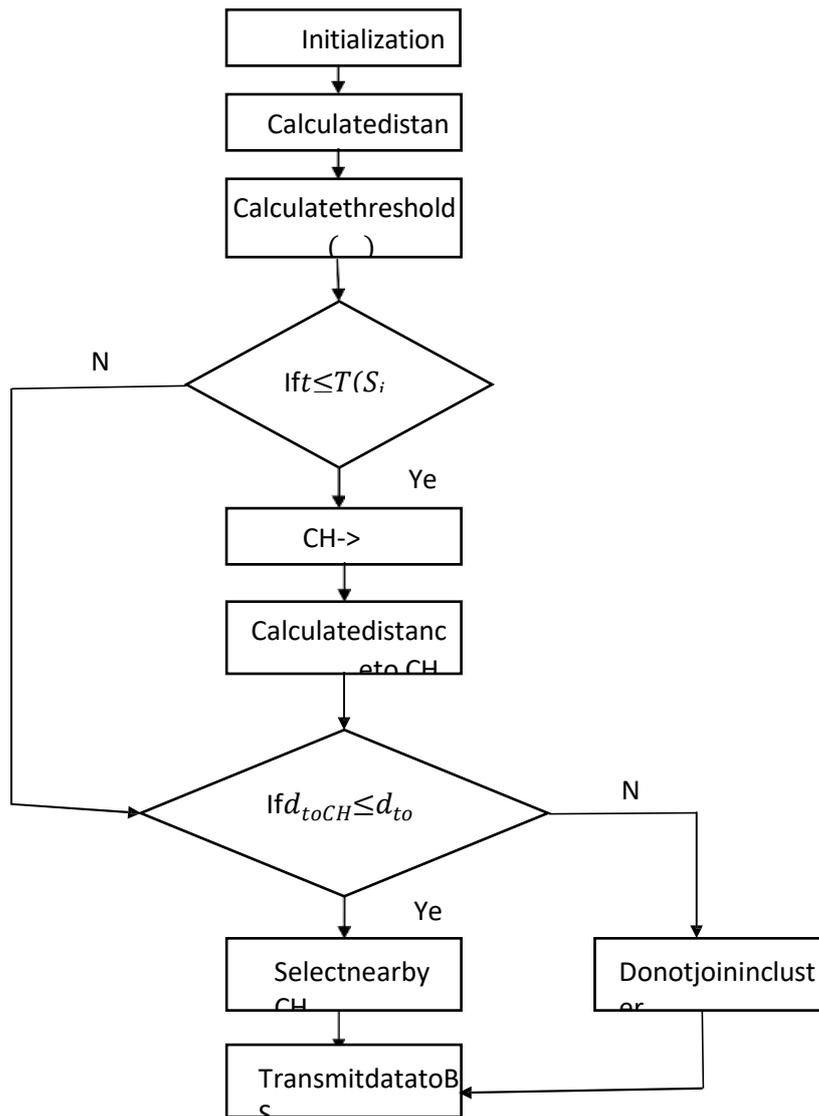


Fig3:Flowdiagramofproposedmethod

As shown in the above Figure 3, the distance to BS and the relevant energy have been determined in addition to the threshold $T(S_i)$. A random number needs to be created with the use of every node, which closer towards the CH and is compared with $T(S_i)$. If the result is getting as lower or equivalent to $T(S_i)$ value, the node has a chance to become CH while determining the distance to CH. In the cluster formation process, the nodes, which are closer to BS will be participated rather than the CH and data transmit to BS.

Delaybasedrelaynodeselectionusing DPSO

Delay is demonstrated as the period of transmitting the data packets from source(S) to destination (D). The delay D(S) involves different types of delays, like transmission delay D(t), propagation delay D(P), and queuing delay average D(Q) per intermediate data disseminator. It is formulated as follows:

$$D(S) = (D(t) + D(P) + D(Q)) * K$$

$$K = \text{constant}$$

Where, K refers to the constant of a network, i.e. $K = D(Q) + D(P) + D(t)$. The network QoS is also affected the timely data delivery as delay is impacted directly in addition to the network lifetime, throughput, and energy consumption, etc. During the data transmission, the delay minimization is essential for improving the network quality.

Delayconstrained Particleswarmoptimization

The major inspired activities of proposing Particle Swarm Optimization (PSO) are the natural life events, like bird flocking, fish schooling, etc. In these activities, all birds or fishes have been travelled in a group with no collisions. This is due to the following the group by each member through the adjustment of position and velocity.

A swarm of a predefined size of particles (say N_p) is contained in the PSO. A complete solution is given by each particle for the problem of multidimensional optimization. However, all particles having the equal dimension. The particle P_i includes the velocity V_{id} , and position $X_{id}, 1 \leq d \leq D$ in the hyperspace with d th dimension. The below expression is used for representation of population's i th particle, i.e. P_i .

$$P_i = [X_{i,1}, X_{i,2}, X_{i,3}, \dots, X_{i,D}]$$

The evaluation of solution quality for the problem is performed based on the determination of each particle using the fitness function. Usually, P_i follows its own best, like personal best P_{best} and global best G_{best} with the updated velocities and positions to reach the global best position. At each iteration, the values for velocity V_{id} and position X_{id} have been updated in the d th dimension.

$$V_{i,d}(t) = w * V_{i,d}(t-1) + C_1 * R_1 * (X_{pbest,i,d} - X_{i,d}(t-1)) + C_2 * R_2 * (X_{Gbest,i,d} - X_{i,d}(t-1))$$

$$X_{i,d}(t) = X_{i,d}(t-1) + V_{i,d}(t)$$

Where, R_1 and R_2 indicate the two random number, which are under uniform distribution within the range $[0,1]$ and C_1 and C_2 are two non-negative constants, known as acceleration factors while w is the inertial weight. The repetition of update process is performed iteratively unless reaching to the G_{best} with acceptable value or fixed number of iterations.

Energy efficient relay selection using DPSO

The particle initialization is contained in the DPSO-based relay selection method. However, the fitness function determines using the velocity and position values' updating.

Particle Initialization

The encoding of each particle is performed in a network (path is contained from each CH) and each particle P_i has dimension D (number of CHs). From a uniform distribution, each CH is initialized as $P_i | 1 \leq i \leq N_p$ with randomly generated number within the range of $[0, 1]$.

Derivation of Fitness Function

The individual particle of the population is evaluated using the fitness function for updating the particles with personal best and global best values on a periodical basis. The major objectives of the proposed technique are included the reduced node cost and minimized end-to-end delay.

$$\text{objective1} = \min\{NCOST_i; 1 \leq i \leq n\}$$

$$\text{objective2} = \min\{NDELAY_i; 1 \leq i \leq n\}$$

Node cost: This is the cost value to be determined based on a path between cluster head nodes. It is formulated as follows:

$$C_i = \left(\frac{1}{E_{res} + E_{agg} + E_{rcv} + E_{trans}} \right) +$$

Where, E_{res} is the nodes' remaining energy, E_{agg} is the expanded energy of node i according to the messages' aggregation from the members, E_{rcv} represents the node i 's consumed energy for reception of messages from other nodes, and E_{trans} refers to the node i 's energy that consumed to transmit the messages from one node to another node within a distance.

End-to-end delay: For a wireless route, the end-to-end delay determines using the delay between source and destination nodes. It includes the processing delay, queuing delay, and propagation delay.

$$NDELAY_{i,j} = \sum_{k=1}^n \left(\left(\frac{1}{\alpha_1 - \alpha_2} \right) + \frac{1}{\text{PROSPEED}} + \frac{D(i,j)}{BW_{link}} \right)$$

Where, $D(i,j)$ refers to the distance between nodes, $PROSPEED$ represents the propagation speed, BW_{link} is bandwidth link, and α_1 & α_2 represent the constants.

In this approach, the weight W_i is multiplied with each objective. To be converted the multi objectives into a single scalar objective function, all values have been added as follows:

$$F(i) = W_1 * \text{objective1} + W_2 * \text{objective2}$$

W_1 and W_2 values maintain within a range of $[0,1]$ to maximize the value of fitness.

$$j = [()]$$

The position of a particle is better with the reduced value of fitness. To get the new position of particle P_i , the fitness function is used. It's being replaced the P_{best} value itself if the P_{best} fitness value is much greater than the current fitness value. The process of updating is carried out as follows:

$$= \begin{cases} (() < ()) \\ p_{best_i} & otherwise \end{cases}$$

The updating process of global best is as follows:

$$= \begin{cases} (() < ()) \\ G_{best} & otherwise \end{cases}$$

Until the criteria of termination are fulfilled, the positions and velocity update iteratively. After making the termination into the DPSO relay selection algorithm, the final solution for routing represents using the particle G_{best} .

Algorithm

For all nodes 'n'

Calculate

Calculate random number

$if(t \leq T(S_i))$

$CH \rightarrow n_i$

Calculate

If($<$)

Select CH and join the cluster

Else

Nodes do not participate in the cluster

End for

Data transmission phase DPSO

Initialize particles $P_i \quad 1 \leq i \leq N_p$

$= 1$ do

Calculate fitness ()

=

If () < ()

=

If () <

= ()

End

Compute relay nodes using

End for

IV. Results and Discussions

The proposed algorithm EA-LEACH is evaluated against the existing protocols, such as IEE-LEACH and DRE-LEACH. In this study, four different scalability networks, like 250, 200, 150, 100, and 50 nodes are considered to analyze the energy efficiency. The principles of load balancing and network lifespan have been incorporated to determine the EA-LEACH algorithm's energy efficiency. To reflect the performance of EA-LEACH, the sensor nodes' energy consumption rate and average energy per round are taken into account under the conditions of timespan from the network operations initiation to first node dies (FND) and the timespan for reaching All Nodes Depleted (AND). EA-LEACH algorithm's impact is illustrated based on the ten simulation reports for energy dissipation, network lifespan, and network scalability. To enhance the reliability, the redundant simulation runs have been performed. As shown in below Table 1, the simulation parameters are considered.

Table 1: Simulation parameters and their corresponding values

Parameters	Value
Simulation area	1000 mx 1000 m
Number of nodes	50-250
Node deposition	Random
Initial energy of each node	100 (j)
Packetsize	512 bytes
Clusters	8
Traffic protocol	CBR
Transmission protocol	UDP
Routing protocol	DRE-LEACH, IEE-LEACH, EA-LEACH

By comparing with the previous methods, like DRE-LEACH and IEE-LEACH, the proposed protocol of EA-LEACH protocol performance is analyzed. For simulation purpose, a total number of 50 to 250 sensor nodes are deployed randomly. The mobility is not given for sensor node as the network is wireless. The total number of fixed clusters is eight. In the Omni-Antenna direction, each node considers about the initial energy capacity over the network. To produce the constant traffic during the transmission of data, the traffic generator of CBR (constant bit rate) is used. Since the acknowledgement is not required from receiver node, UDP performs the data communication. The proposed protocol performance is made comparison with the other protocols, like DRE-LEACH and IEE-LEACH.

Scalability

EA-LEACH algorithm effects on network scalability are illustrated by reporting the network lifespan and the criteria of 10 iterations for delivered packets with diverse initiation positions of sensor nodes. The proposed algorithm of EA-LEACH lifespan is validated to maintain the network functioning for given increased nodes. The successful rate of delivering the data packets is higher when the network connectivity is higher.

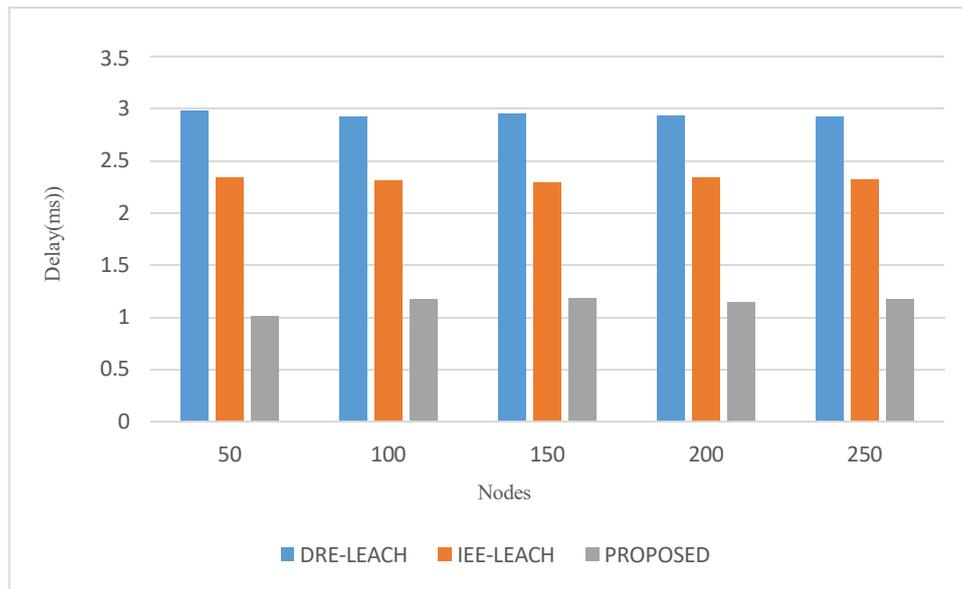


Fig4:Performanceof Delay

Figure 4 depicts the end-to-end delay simulation results for proposed EA-LEACH protocol and other existing methods, like DRE-LEACH and IEE-LEACH. The chances of making the frequent CH reselection would be reduced with the CH selection based on random number; relay selection is improved for data communication using delay-based PSO. Therefore, the network’s end-to-end delay is minimized. In the network, the minimum average delay was reported as 0.134 ms, but the earlier techniques experience higher delay than the proposed technique.

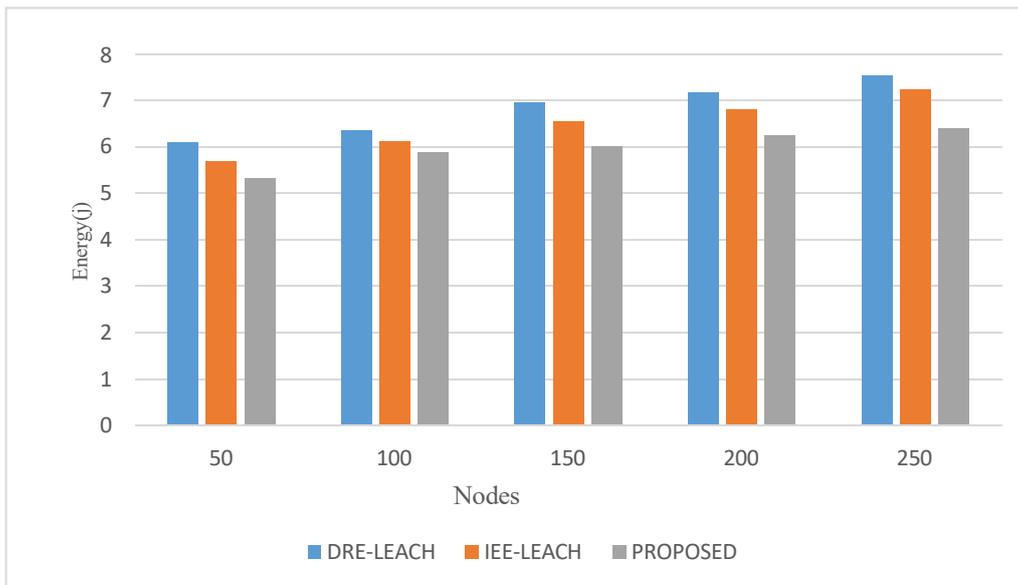


Fig5:Energyconsumption

The consumed energy results are depicted in the Figure 5. In this protocol, the nodes are energized with 100j for longer run and consumed it during each network activity. The energy consumption is controlled with the efficient selection of relay nodes and CH nodes as well. As mentioned in the above graphs, the proposed technique saves the considerable amount of energy compared to the earlier techniques.

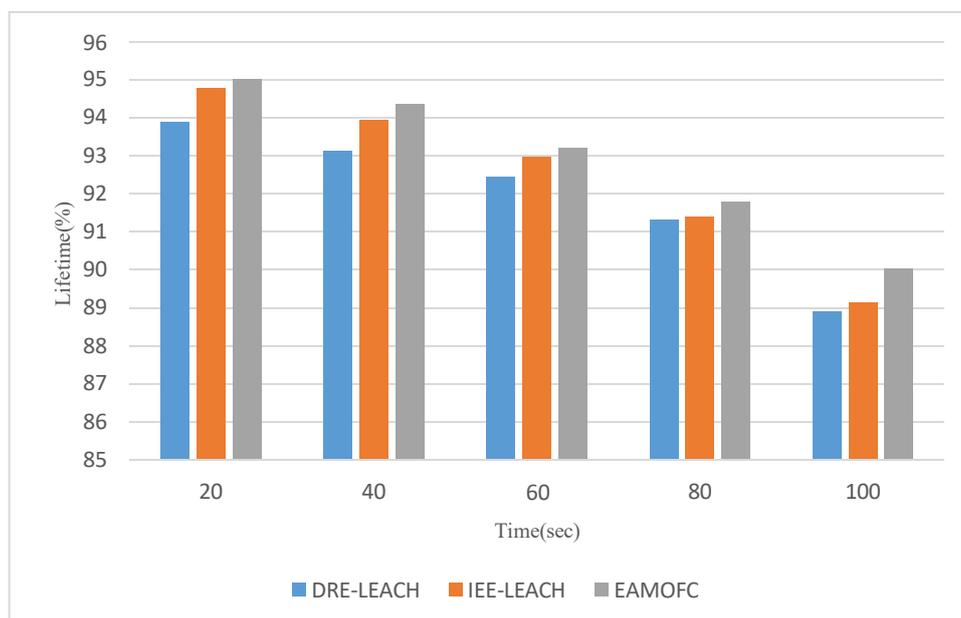


Fig6:Lifetimeofnetwork

Network lifetime describes as the period, during which the first node is running out of energy or the network is being operational. The remaining energy availability of nodes is relevant to the network lifetime once the network operation is stopped. The increased remaining energy enhances the network lifetime. With the proposed method, the overall lifetime of a network is

increased than the earlier methods, such as IEE-LEACH and DRE-LEACH. Figure 6 illustrates the network lifetime results for proposed technique.

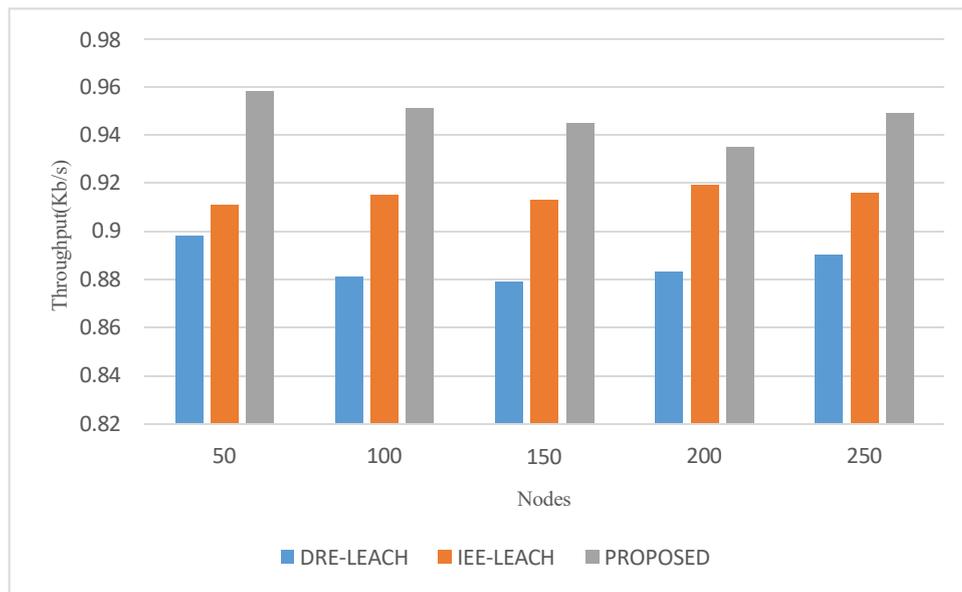


Fig7: Network performance

Network throughput or performance describes as the amount of data that could be transmitted among sensor nodes in a certain period. The data delivery with higher amount is ensured the increased throughput. The listed values in the above table prove that the throughput rate is increased than the previous techniques. The average throughput rate of 144 kbps is maintained with the proposed technique and it is higher than the earlier methods as shown in the Figure 7.

Conclusion

The random numbers are considered to select the Cluster Heads (CHs) in case of conventional LEACH protocol. It may lead to the causing of earlier death for nodes, which having lower residual energy due to the similar priorities given for all nodes to be a cluster head irrespective of their residual energies. To overcome this limitation, a novel modified routing protocol is proposed, i.e. improved energy adjusted LEACH (EA-LEACH) protocol, which takes into account the residual energy of nodes and their average energies. The proposed EA-LEACH protocol is accounted for optimal CHs and not allowing the nodes to participate in the cluster creation when they are much closer to the BS. The improved PSO (DPSO) utilizes to select the efficient relay node and enhance the energy efficiency during the transmission of data that results in minimized and balanced energy consumption. To select the relay node efficiently, the node cost and end-to-end delay are the significant parameters for DPSO. The better performance is achieved with the proposed technique based on the simulation results for communication quality, consumption of energy, and network lifetime.

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