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Energy Efficient Distance Based Multiple Cluster Head-Selection Approach in WSN

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***Abstract*– WSN is a growing technical platform having remarkable applications in various fields like structural monitoring, health monitoring, military, home networks, agriculture, etc. One of the limits of WS nodes has restricted energy resource. One way to minimize the power consumption is clustering which prolongs the time of the network. In this research work, we consider Energy Efficient Distance Based Multiple Cluster Head Selection Approach (EDMCHSA) in WSN. In this, a node will elect itself as a CH if it has sufficient transmission energy and distance from current to all CHs is greater than the minimum distance (D) among the CHs. The distance between the CH is, and other nodes are considered so that no lone nodes are left and a proper CH will be selected. Cluster heads (CHs) communicate with other remaining nodes. One cluster head leader, among all cluster heads, will be selected if it has sufficient transmission energy greater than the average residual energy of the rest of the nodes and distance of CHL to the BS is less than the average distance of other nodes. CHs will receive the packets, aggregate these packets, and transfer all aggregated packets to CHL. CHL will again aggregate the received packets and send to BS. The objective of this effort is to enhance lifespan WSN. It is shown by simulation that when we Compare LEACH-B and EDMCHSA, the energy utilization of WSN is decreased 20% in EDMCHSA.**

***Index Terms*– Wireless Sensor Network, Efficient Power Utilization, Clustering Protocols, Lifetime of the Network, LEACH-B and EDMCHSA**

I. INTRODUCTION

THE wireless sensor network is a set of hundreds of thousands of sensor link. This link is the wireless medium used to deploy to perform data gathering task from the devices which scattered around in the environment, then gathered data processed and finally distributed among nodes. The growth of WSN has been breath-taking since last years. WSN plays a vital role in our life and has become part of our life activities including homes, healthcare and food production, traffic and vehicles, controlling and monitoring all these activities. WSN is one of the main technologies of the twenty-first century which has a wide range of applications from health-care to surveillance applications. WSN is the complex combinations of many tiny sensor nodes and sink node that consumes the energy for sensing the condition and environment, computation and communication of data and information. Nodes sense the data and send the packets to the sink node. WSN has a large number of nodes varying from hundreds to thousands and a sink nodes/base station. The radio wave is implemented in order to transfer data from transmitter to receiver. So, batteries are the main resources for these sensor elements. These irreplaceable batteries have restricted process power and capability. Battery. Therefore, we have limited processing power and storage. Network life directly depends upon energy consumption. WSN is an infrastructure less scenario because there is no central coordination to these types of networks; these networks are found in that area in which human intervention is not possible. Energy consumption is the amount of required power supply for the computation and communication of data packet to transmit from a node to the base station. Network life directly depends upon energy consumption in Numerous ways that are planned to utilize energy all the additional effectively. In WSN energy consumption and clustering are two major concerned to prolong the network lifetime. Many researchers have worked out to find out an effective clustering protocol to save energy in consumption. Cluster head selection is a main important step in energy consumption management. Routing protocols that are based on the cluster are classified into two clustering algorithms categories (centralized and decentralized) [1].

In centralized clustering, the sink node is responsible for making clusters in every round. Sink nodes keep location information and energy status of every sensor node. The sink node can collect data from the sensors elements in the community, select a CH, and sort clusters. The centralized clustering is not appropriate to do agglomeration for a massive variety of a large number of tinny sensor nodes. One of the examples of centralized clustering protocol is, BCDCP (Base-Station Controlled Dynamic Clustering Protocol) which has a novel sink. Sink node receives the information of nodes' location and energy status from each node. Sink node selects a CH node and sends a broadcast a message including a CH ID for each node. Cluster nodes check the CH ID; if it is matched to its Id, it becomes the part of that CH cluster. More overheads are included in ID checking and sending location information of the nodes and energy status of the nodes to the base node.

Therefore, in BCDCP maximize the planning overhead, complexity and power usage in a large number of nodes in WSN. It is typically used for small zone systems [1], [2], [3].

In a centralized cluster, the sink node is not the organizer to make CHs and clusters. Base station only receives the information and message sent from the cluster head. The two-level hierarchical data structure is used to make clusters and choose CHs. In the steady phase (first level), CH is selected, and the process clustering is performed. In the second level, CHs send information and messages to BS. LEACH (Low-Energy Adaptive Clustering-Hierarchy) is the basic decentralized and homogenous based clustering protocol in WSN. LEACH is one of a conventional protocol used to increase the energy efficiency in WSN. The hierarchical protocol can be used for a wide range of area networks. In the hierarchical protocol, single hop structure is used. CH is selected randomly which causes higher communication overhead. There is no strategy to keep CHs positioning and distribution of nodes in the cluster [4]. The efficiency of LEACH improved in CLERP protocol, BCDCP protocol, GPSR protocol, TEEN, and ECHERP (Equalized-Cluster-Head Election-Routing-Protocol). In these protocols, multi-hop routing is used [5],[6].

We proposed a new “Energy Efficient Distance Based Multiple Cluster Head Selection Approach (EDMCHSA)” approach to form a balanced cluster and prolong the lifespan of the network. In this, a node will elect itself as a CH if it has sufficient transmission energy and distance from current to all CHs is greater than the minimum distance (D) among the CHs. The distance between the CH is, and other nodes are considered so that no lone nodes are left, and a proper CH will be selected. Cluster heads (CHs) communicate with other remaining nodes. One cluster head leader, among all cluster heads, will be selected if it has sufficient transmission energy greater than the average residual energy of the rest of the nodes and distance of CH to the BS is less than the average distance of other nodes. CHs will receive the packets, aggregate these packets, and transfer all aggregated packets to CHL. CHL will again aggregate the received packets and send to BS.

The paper structure is in the following sections. Related clustering protocols are presented in section II. In section III, proposed work is described. The proposed approach is compared with LEACH-B and results are shown in section IV. In section V, the conclusion of the proposed work and Future direction related to proposed work is outlined. At the end of the paper, citations and references of the papers referenced in this paper are entitled.

II. RELATED WORK

The ever-increasing demands of WSN have motivated the researchers to explore, how they can enhance the lifespan of network and reduce the consumption of power [7].

The most challenging factor in WSN is to design a network in that way that it consumes less power for computation and communication. The development of protocols to achieve energy efficiency is, therefore, more important for the designing of WSNs. Most of the energy is consumed when nodes are in a state of listening and transmitting state. Many algorithms and routing protocols are proposed to minimize energy utilization. A routing protocol describes the set of rules and method for the selection of route, routers, and method/manner of communication in networks. Nodes connected to this network share this information. The careful specifications that a protocol has, comprise of the manner during which loops of routing are avoided, the way during which ideal routes are chosen, info of the hop prices are employed, the period required for convergence of routing arrival, the protocols quantifiability and many alternative options.

A) LEACH (Low Energy Adaptive Clustering Hierarchy)

LEACH is a very first conventional Protocol. LEACH protocol works in two-level hierarchical clustering in a different number of rounds. There is two phases in LEACH protocols (Setup and steady) In the setup phase, one cluster head is selected in every cluster. The cluster head is selected randomly in every round. In each round, every node selects a random number in range o to 1, and a threshold value T(n) is determined as given in equation (1). A node selects itself as a CH if the chosen random number is less than the threshold value.

$$T(n)=\begin{cases} \frac{P}{1-P\left(r mod \frac{1}{P}\right)} & if\ n \in G \\ 0 & otherwise \end{cases} \qquad (1)$$

r= round number

p= %age of Cluster-Heads

G= set of nodes to be selected as CH

After CH selection, CH broadcast an advertisement message to all its neighbor node to tell about its selection as a CH node. CH sends an advertisement request to all other nodes to become cluster nodes (CNs) of its cluster. CNs will be part of that cluster which CH is near and has strong signal strength. Cluster heads (CHs) communicate with other remaining nodes of its cluster and assigns the TDMA slots to all nodes. Then set-up phase of this round is completed. After that steady phase is started. Cluster heads (CHs) collect the data from its cluster nodes, aggregate, and send it to the sink node [8].

B) LEACH-B

LEACH-B is the new version of LEACH proposed by Tong and Tang proposed. In LEACH, number of CHs are varying in every round. In LEACH-B, number of CHs are balanced. Number of CHs in a round is calculated as in given in Eq. (2).

$$K = N *p \qquad (2)$$

Here,

N= total number of nodes

K= number of CHs in a rounds

P= percentage of the desired amount of Cluster-Heads

Every elected CH sends an ADV packet and its residual energy or percentage of residual energy it is a neighbor node to tell about its selection as a CH node. In a round, if the total number of CHs are greater than N*p, then some of the CHs having lowest remaining energy will resign from headship. In a round, if the total number of CHs are less than N*p, then some of the CHs having the greatest remaining energy will elect themselves as CH. A node will elect itself again after a specific Twait time as calculated in Eq. (3).

$$Twait = k/Eresidual \qquad (3)$$

Here,

k = wait time factor

After Cluster heads (CHs) selection, CH communicates with other remaining nodes of its cluster and assigns the TDMA slots to all nodes. Then set-up phase of this round is completed. After that steady phase is started. Cluster heads (CHs) collects the data from its cluster nodes, aggregate, and send it to the sink node [9],[10].

C) TEEN (Threshold Sensitive Energy Efficient Sensor Network Protocol)

In the TEENs hierarchical mode in which sensors sense the attribute when there is a sudden change in environmental attributes. CH nodes are selected, and after selection, CH sends Hard Threshold (HT) and Soft Thresholds (ST) to the member's nodes. HT value is the least point in the range of attribute. It is supposed that all the attributes value is higher than the HT. Sensor node turns its transmitter on and tells its CH when the value exceeds the hard threshold value then every. The minor change in sensed attributes value is called ST. Sensor node turns its transmitter on and forwards the data when ST occur. The nodes monitor the environment regularly. When one of the attributes sets parameters comes up to the hard threshold value, then cluster node power on transmitter and data is forwarded. The sensed value is saved in an internal variable that is also called a sensed value (SV). Its most important advantage is that it is used in the conditions that change abruptly. Sensor elements sense the environment regularly but send the data only when SV is higher than HT value. In this way, energy is maintained in TEEN. The rate of transmission is reduced more by ST because it happens only when there is very small or no change in SV. Its disadvantage is that if SV is not greater than HT, then nodes cannot transmit data to cluster head and hence CH can never identify if the node dies. It consumes much energy in large-area networks and when there are few layers in the hierarchy but the transmission is smaller if the number of layers is increased. Cluster head uses more energy as it has to do the additional computation. Every node of the cluster can act as a CH for some time, so the power/energy is distributed uniformly. A precise and correct network picture is gained by setting ST smaller. However, in this transmission more frequent and more energy is consumed. A transmission slot must be allotted to every cluster node to send data to CH by using the TDMA scheme. CDMA scheme is used for BS and CH communication to avoid collisions [11], [12].

D) APTEEN (Adaptive Threshold Sensitive Energy Efficient Sensor Network Protocol)

APTEEN protocol is a new modified version of TEEN. APTEEN is suitable for the application which is time sensitive. In those applications, data is collected periodically. After the selection of CH nodes, CH broadcasts ADV message to all other nodes along with ST and HT value, transmission schedule, attributes and count time parameter/ counter time (CT). As sensor element senses the environment regularly. When the sensed value when it is greater than HT then it is saved in a variable called sensed variable (SV). A transmission slot must be allotted to every cluster node to send data to CH by using the TDMA scheme. The number of nodes the clusters are different in number from cluster to cluster. The cluster having more nodes take more time for transmission. A pair of nodes is formed if two neighboring nodes have to transmit the same data. In the pair, there are two states of nodes (active node and sleep node). Data is transferred by the active node, and sleep node will remain in sleep mode. Its main advantage is that nodes energy consumption is lessened by careful selection of threshold values and count time. Collisions during communication between base station and cluster heads are avoided by modified CDMA. Its drawback is that its complexity is increased due to the implementation of count time parameter and threshold functions [11], [12].

E) BCDCP (Base Station Controlled Dynamic Clustering Protocol)

This protocol forms balanced clusters. For this, the energy status of all network nodes is sent to BS, and then the routing path is constructed. After this, the average energy level is computed by the base station, and then nodes with greater power as compared to the average value are selected. In this, CHs are changed arbitrarily by BS and clusters communicate with one another through cluster to cluster routing path. Data fusion, aggregation, and compression are achieved by this. This protocol uses Iterative-Cluster-Splitting-Algorithm to achieve the perfect amount of clusters & to divide the load uniformly among all clusters. Many CH-CH routing pathways are made, and finally, a schedule for every cluster is made and is sent to all sensor nodes. During the data communication phase, the data after processing is sent from nodes to BS by CHCH routing pathway [13]. All cluster heads serve almost the same number of nodes. Following advantages are achieved by this:

- CH overload is avoided
- CHs are placed uniformly in the whole network
- A Cluster-Head-to-Cluster-Head (CH-CH) communication is used for transmission of data packets to BS/sink

F) ResEn (Residual Energy)

Tuah et al. proposed a new protocol named as Residual Energy (ResEn) algorithm that works as LEACH only selection criteria of LEACH is modified in modifies the cluster [14]. Residual energy of the node is considered in the selection of CH. The formula to calculate a threshold value in ResEn and LEACH is almost the same. Percentage of residual energy of each node is included to choose CHs in ResEn. A node knows the percentage of remaining power given as Ecur/Einit.

The threshold value is shown in Eq. (4).

$$Ti(t) = \begin{cases} \frac{P}{1-P\left(r mod \frac{1}{P}\right)} \times \frac{\text{Ecur}}{\text{Einit}} & \forall_i \in G \\ 0 & \forall_i \notin G \end{cases} \quad (4)$$

Ecur = current value of Energy resource

Einit = initial energy

P= Percentage of CH

G= set of sensor nodes to be selected as CH

However, ResEn protocol increases the timespan of the network as compared to LEACH.

III. PROPOSED METHODOLOGY

In our proposed "Energy Efficient Distance Based Multiple Cluster Head-Selection Approach (EDMCHSA)" we took in consideration, the residual energy of all nodes, distance among the CHs and member node, average residual energy and the average distance of CHs for balance clustering. A node will elect itself as a CH if it has sufficient transmission energy and distance from current to all CHs is greater than the minimum distance among the CHs. The distance between the CH is, and other nodes are considered so that no lone nodes are left and a proper CH will be selected. Cluster heads (CHs) communicate with other remaining nodes. One cluster head leader, among all cluster heads, will be selected if it has sufficient transmission power that is greater than the average residual power of the rest of the nodes and distance from CH to the BS is less than the average distance of other nodes. CHs will receive the packets, aggregate these packets, and transfer all aggregated packets to CHL. CHL will again aggregate the received packets and send to BS.This will save overall energy and prolong the lifespan of WSN. The proposed methodology is shown in Fig. 1.

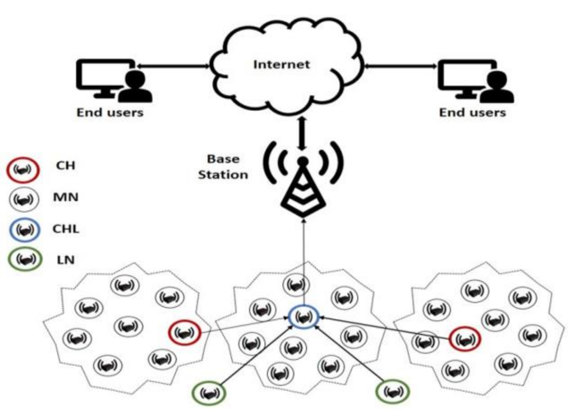

Figure 1: EDMCHSA Model

The proposed research will be carried out in two following levels:

- Setup phase
- Data transmission phase

Setup Phase: Set up phase will be carried out in the following steps.

- Selection of CH
- Formation of Cluster
- Communication of CHs to other nodes
- Selection of CHL

Selection of CH: In CH selection process, all distributed nodes elect itself as a CH by picking up a random number between 0 and 1. If this randomly chosen number is less than a threshold value $T_{i,}$ then it is selected as a CH. The threshold value is calculated as in eq. (5).

$$T_i = \begin{cases} \frac{P}{1-P\left(r mod \frac{1}{P}\right)} & \forall_i \in G \; or \; F(i) = 1 \\ 0 & \forall_i \notin G \; or \; F(i) = 0 \end{cases} \quad (5)$$

P= Probability of CH in all N nodes

r= number of round

G= set of sensor nodes to be selected as CH

F(i)= Flag used to check either current selected node had become CH or not before current round

CH selection is the main concern because CH is responsible for the transmission. An improper CH selection leads to network failure because if CH is failed, then all transmission related is failed. In the above equation, energy consumption is not taken in corned for CH selection. All nodes may be elected as CH at the start of a round having probability P to become a CH. However, only those nodes is selected as CH which have sufficient energy for the transmission of data packets. In the beginning, all N nodes are randomly distributed in a square area of length(X). We suppose BS is located at the center of the network region. In the first round, CH is selected randomly. In other rounds, a node will elect itself as a CH if it has sufficient transmission energy and distance from current to all CHs is greater than the minimum distance among the CHs. The distance between the CH is, and other nodes are considered so that no lone nodes are left and a proper CH will be selected. Number of CHs is calculated as shown in Eq. (6).

$$CH_{opt} = \begin{cases} \sqrt{\frac{N}{2\pi}} \frac{M}{d_{toBS}} & for \; d_{toBS} \leq d_0 \\ \sqrt{\frac{N}{2\pi}} \sqrt{\frac{\mathrm{E_{fs}}}{\mathrm{E_{mp}}}} \frac{M}{d_{toBS}} & for \; d_{toBS} > d_0 \end{cases} \quad (6)$$

Here, $d_0$threshold distance between transmitter and receiver which is calculated using the first-order wireless transmission model as shown in Eq. (7).

$$d_0 = \sqrt{\frac{\mathrm{E_{fs}}}{\mathrm{E_{mp}}}} \quad (7)$$

Here E_{fs} is free space transmission model and E_{mp} Multiple path transmission models. So, the probability of a node to become a CH is calculated as shown in Eq. (8).

$$P = \frac{CH_{opt}}{N} \quad (8)$$

Here, CH_{opt}= Total number of nodes which may become CH in network

N= Total number of nodes in the network

A node which has become a CH in $\frac{1}{p}$ ra ound cannot become a CH in next$\frac{1}{p}$. If there are more CHs than CH_{op}, some will resign from headship till CHs number becomes less than $CH_{opt.}$ The Cluster-Heads with least rresidual energy will resign. This is done by getting the residual energy or residual energy percentage with ADV packets. As the the capability of a node to become a CH is decreased gradually so the probability of rest of the nodes is increased gradually. After $\frac{1}{p}$ all nodes will be able to become a CH once again.

Formation of Cluster:

Clusters of nodes are formed after proper selection of CHs. CHs will send a broadcast message to all its neighbor node to tell about its selection as a CH node.CH will send an advertisement request (ADV packet) to all other nodes to become CNs of its cluster. Member nodes send JOIN REQ message packet to be part of that cluster which CH is near to it having strong sending signal strength and become CNs (cluster nodes) of that cluster; cluster heads (CHs) communicate with other remaining nodes of its cluster and assigns the TDMA slots to all nodes. Some member nodes could not receive any ADV packet because of long distance among the nodes or weak signal strength. Such nodes are known as Lone Nodes, and this node directly communicates with the base station.

Selection of Cluster Head Leader (CHL):

Cluster-Head receives data packets from cluster nodes and fuses that data packets through the process of aggregation and compression. More energy is consumed in data transmission then data aggregation and data compression. In the same way, more energy is consumed if the distance between nodes is large. One Cluster Head Leader is selected among all CHs base of maximum residual energy. CHL will send a broadcast message to all CHs tell about its selection as a CHL node. CHL will send an advertisement request (ADV packet) to all CHs and Lone nodes. CHs and Lone nodes send JOIN REQ message packet to communicate with CHL. CHL communicate with CHs and Lone nodes by assigning a slot to every CHs and Lone nodes using TDMA approach. CHL is the only nodes which communicate directly to the base station instead of all CHs. In this way, overall transmission energy is decreased which result as prolong network lifetime. In our proposed approach, a CH becomes a CHL by considering two main parameters.

- Residual Energy
- Distance to BS

Residual energy is the amount of the maximum remaining energy of a node to perform the transmission as in Eq. (9).

$$E_{res} = E_{init} - E_{con} \qquad (9)$$

Here,

E_{res}= Residual energy of a node

E_{init}= Initial energy of a node

E_{con}= Energy of a consumed in previous round

A node is selected as a CH when it satisfies two equations.

1. $E_{res} > E_{avg}$
2. $d_{toBS} \leq d_{avg}$

Here, E_{avg} is the average current energy of all nodes in the network calculated as shown in Eq. (10).

$$E_{avg} = \sum_{i=0}^{i=N} E(i)_{cur} \qquad (10)$$

d_{avg} is the average distance of all nodes distance to base station calculated as shown in Eq. (11).

$$d_{avg} = \sum_{i=0}^{i=N} d(i)_{toBS} \qquad (11)$$

When a node it satisfies above two equations then it will be selected as CHL node. Otherwise, it will be simply a CH node.

Data Transmission (Steady) Phase:

Data transmission phase is also known as the steady state. In this phase, all nodes transfer their sensed data to their respective cluster heads. CHs will aggregate and transfer all information to CHL creating Time Division Multiple Access (TDMA) schedule. A specific time duration will be given to each sensor node to transfer data. CHL will send data to the base station (BS) by creating another Time Division Multiple Access (TDMA) schedule.

Total energy consumed to send and receive L bits of data is calculated using equation (12) and (13) respectively.

$$E_{Tx}(\mathrm{L,d}) = \begin{cases} L \times \mathrm{E_{elec}} + L \times \mathrm{E}_{fc} \times d^2 & for\ d < d_0 \\ L \times \mathrm{E_{elec}} + L \times \mathrm{E}_{mp} \times d^4 & for\ d \geq d_0 \end{cases} \qquad (12)$$

$$E_{Rx}(\mathrm{L,d}) = L \times \mathrm{E_{elec}} \qquad (13)$$

Here, d is the distance between transmitter and receiver

IV. SIMULATION RESULTS AND DISCUSSIONS

The proposed model is tested by using MATLAB 9.2 (R2017a), and results are compared with LEACH- B. The networks parameters are presented in table 5.1. A specific scenario will have different parameters.

Table I: Simulation Network Parameters

Parameters	Values
Area (m^2)	100x100
Base Location	(50,175)
Node Mobility	Static
Packet size (L)	4000 bits
Nodes number	100
Initial energy	5 J
Proper percentage of CH nodes (%) p	0.5
Distance (m)	10
Threshold Percentage (%) 30	30
E_{fs}	10pJ/bit/m2
E_{mp}	0.0013pJ/bit/m4
E_{elec}	50nJ/bit
EDA	5nJ/bit

The lifetime of a WSN depends upon energy consumption and live nodes. Network life span is ended when all nodes in the network are died. Fig. 2 shows that the dead nodes in LEACH-B at rounds 8000th are 100 and in EDMCHSA number of dead nodes are 80 at rounds 8000th. So, lifespan in EDMCHSA is has been increased in EDMCHSA comparatively.

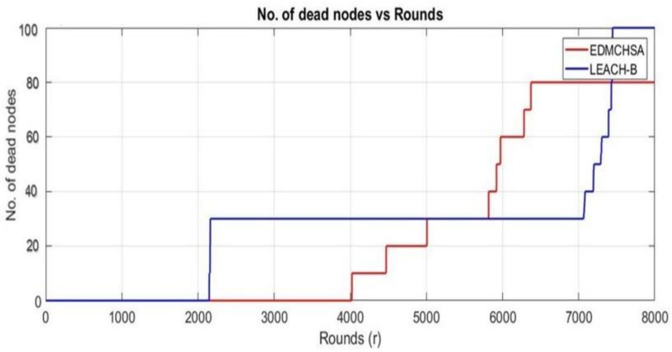

Figure 2: No. of dead nodes vs. Rounds

The Fig. 3 shows that the packets sent to the base station in LEACH-B at rounds 8000th are29000 and in EDMCHSA are 38000 at rounds 8000th. So, maximum packets are delivered in EDMCHSA.

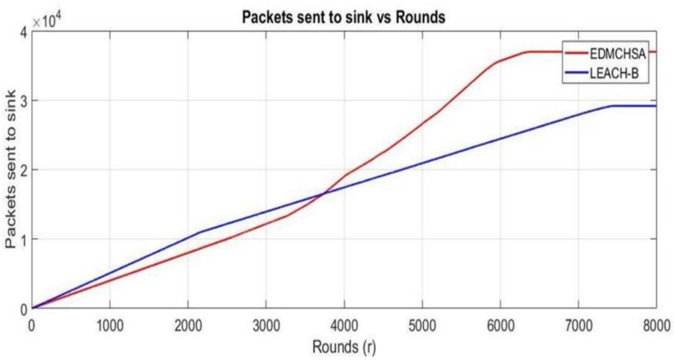

Figure 3: No. Packets sent to BS vs. Rounds

Fig. 4 shows that data packets dropped at BS is 8500 in EDMCHSA, 11600 in LEACH-B. So, it is clear that fewer data packets are dropped in EDMCHSA. That is why throughput in EDMCHSA is greater than in LEACH-B.

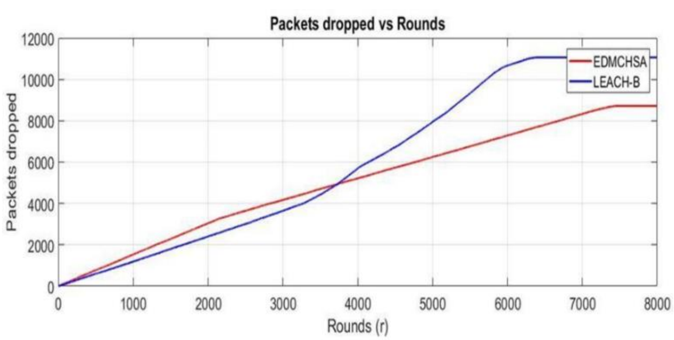

Figure 4: No. Packets dropped vs. Rounds

Fig. 5 shows that packets received at BS in LEACH-B at rounds 8000th are17400 and in EDMCHSA are 29500 at rounds 8000th. So, maximum packets are received in EDMCHSA.

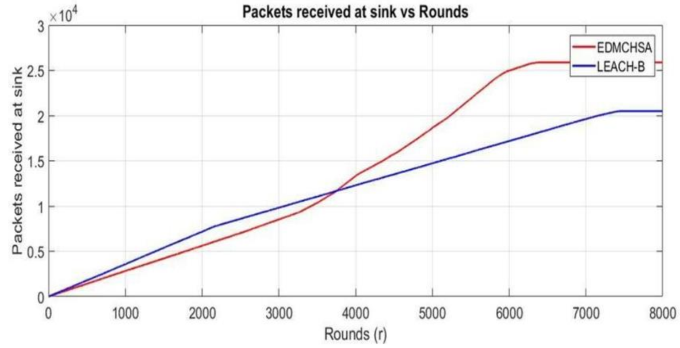

Figure 5: No. Packets Received at BS vs. Rounds

Delay is the time of a network taken to send packets at receiver after leaving the sender. Fig. 6 depicts the delay time in EDMCHSA and LEACH-B. It is clear from the figure that delay time in EDMCHSA is less than delay time in LEACH-B.

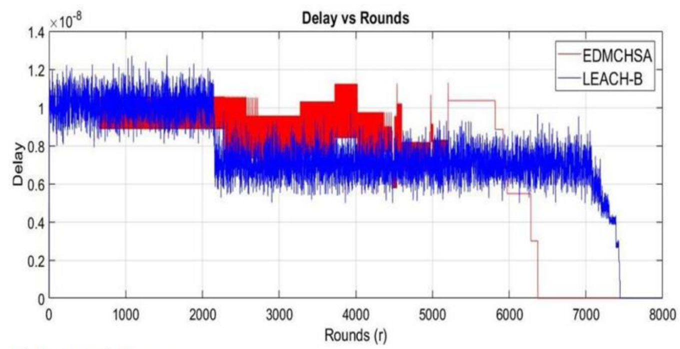

Figure 6: Delay time

Path loss also called path attenuation is accured due to many reasons. It degrades the signal links and propagation of packets. One of the major reasons is the distance between sender and receiver. There are some nodes which could not take part in transmission due to path loss. These nodes are called lone nodes. It is seen in Fig. 7 that path loss in LEACH-B is more than in EDMCHSA. So, EDMCHSA gives better result and throughput than in LEACH-B. Life span in EDMCHSA will be increased as maximum nodes are taking parts communication.

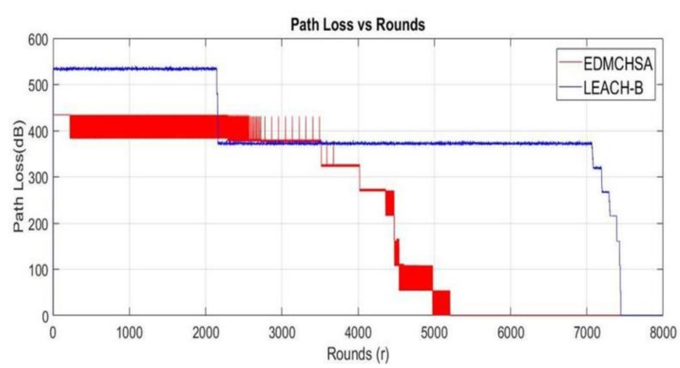

Figure 7: Path Loss vs. Rounds

Residual energy is the amount of remaining energy of nodes for the next transmission. It is shown in Fig. 8 that residual energy in EDMCHSA is more than in LEACH-B in every round. As we know that the lifetime of a network is inversely proportional to energy consumption. So, it is clear that less energy is consumed in EDMCHSA than in LEACH-B.

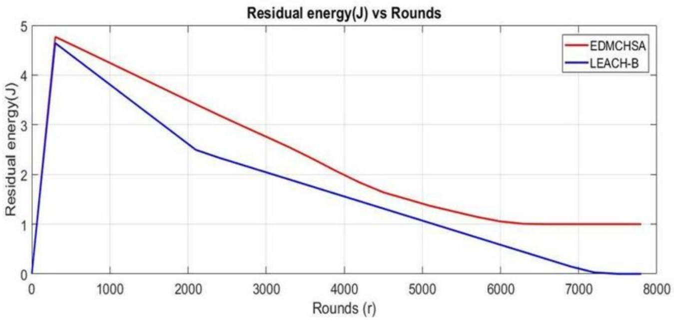

Figure 8: Residual Energy vs. Rounds

V. CONCLUSION AND FUTURE WORK

The simulation results show that EDMCHSA is 20% efficient than LEACH-B. EDMCHSA has increased the lifespan of the WSN. It can complete almost 8000 rounds. In EDMCHSA, the packets sent to BS and received at BS are greater than in LEACH. The overall energy consumed in EDMCHSA is less than in LEACH-B. However, still, there are some nodes that fail to communicate even with CHL. There is a need to design such methods that at least every node must be able to become a member of any cluster. CHL has to do more work, i.e., aggregate data from CHs and lone nodes and as a result of this its energy depletes more quickly. So CHL criteria must be improved. Static nodes are considered in EDMCHSA. Mobile nodes may be considered in EDMCHSA in future work.

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