Distance Based Advanced Energy Efficient Cluster Head Selection Techniques for Wireless Sensor Networks

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Abstract— **Energy is the main constraint for nodes powered by batter, in Wireless Sensor Network (WSN), which can't be replace latter once deployed. To extend the network lifetime, hierarchical routing is employed. In this paper we aim to improve network lifetime by using LEACH based protocol by considering residual energy and distance of nodes in WSN. We adopt dynamic clustering with dynamic selection of cluster heads in first round and static clustering with dynamic selection of cluster heads from second round. One more reason for network to die early is unbalance cluster size, to handle that number of nodes in the cluster is fixed to a predefined value. In this paper, based on Low Energy Adaptive Clustering Hierarchy (LEACH) protocols, distance-based energy aware (DBEA-LEACH) additionally selects a cluster head not only based on distance, but also by examining residual energy of the node greater than the average residual energy level of nodes in the network. We propose the improved LEACH protocol for first node die time (FDT) enhancement. The result's reveal that changes made selection process of a cluster head improves the network efficiency. The approach is to vary the cluster head selection probability along with the threshold level. The protocol works to prolong the first node die time (FND).**

Index Terms— **Low Energy Adaptive Clustering Hierarchy, DBEA-LEACH, FDT-LEACH, Wireless Sensor Network**

I. INTRODUCTION

A wireless sensor network is a network consisting of multiple wireless sensors, also called nodes, which cooperate in sensing some sort of physical or environmental conditions, such as temperature, sound, vibrations, light, movement etc. The individual sensor nodes are small and have limited energy, computational power and memory. These wireless sensor nodes are tiny devices with limited energy, memory, transmission range, and computational power. A base station is usually present in the network, which receives the sensor data from the sensors. Such a base station is usually a powerful computer with more computational power, energy and memory. In most circumstances, wireless sensor networks require some amount of security in order to maintain high survivability and integrity of the network. Several nodes may be tasked with sensing the same phenomenon these nodes may cooperate in a "cluster" where one node is tasked with compressing the sensor result from all the other nodes in the cluster and produce a "collective view" of the cluster on the situation, this is called data aggregation. In wireless sensor network, collection of sensor nodes into a cluster is well-known as clustering. Every cluster contains a Leader called cluster head. A cluster head may be selected by the group of cluster. A cluster head collects the information from the nodes within cluster and send this information to the base station (destination). Clustering can be used as an energy efficient communication protocol.

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Cluster heads consumed more energy due to its role in collecting, removing redundancy, compressing and forwarding the data from cluster to the base station, while remaining nodes only sense the data in the environment and forward it to its cluster head, hence saving more energy. This situation gives rise to unbalanced energy consumption, which causes more drain of energy from cluster heads than cluster nodes in random fashion. Unequal distribution [1] [2] of nodes in the clusters may lead to overload some cluster heads and die soon, leaving the network partitioned. To solve this problem, we restrict clusters with fixed number of member nodes. Because of the above disparities, several new routing mechanisms have been developed and proposed to solve the routing problem in WSNs. A high efficient routing scheme will offer significant power cost reductions and will improve network longevity. Finding and maintaining routes in WSNs is a major issue since energy constraints and unexpected changes in node status (e.g., inefficiency or failure) give rise to frequent and unforeseen topological alterations.

Among the several routing protocols proposed for WSNs, cluster-based algorithms are more effective in meeting WSNs requirements, mainly energy consumption [3-6]. By clustering of sensor nodes into some groups called clusters, SNs of each cluster send their data to specific SNs in the cluster called Cluster Heads (CH). Then, CH nodes transmit gathered information to the BS. Since CH nodes play an important role in the performance of cluster-based routing algorithms, the policy of CH node selection deeply affects network parameters i.e., network lifetime, energy consumption rate.

Figure 1 shows a generalized view of WSNs, which consists of a base station, cluster heads and sensor nodes or a cluster member deployed in a geographical region. Several protocols have applied this concept, i.e., LEACH [7], TEEN [8], and PEGASIS [9]; however, LEACH [7], Low-Energy Adaptive Clustering Hierarchy is one of the most popular cluster-based routing protocols in WSNs. This algorithm uses a random model to selects CH nodes then, non-CH nodes join to the clusters using one-hop transmissions with Time-Division Multiple Access (TDMA).

It should be noted that LEACH algorithm does not consider the residual energy and geographical position of SNs in the CH selection process. This leads to the early death of sensor nodes and the decrease of WSN lifetime.

In this paper, we present our proposal for an improved clustering mechanism of the LEACH routing protocol for energy efficiency, which further advances LEACH routing protocol.

Based on the LEACH routing protocol, we propose two new distance-based clustering routing protocols. Our proposed routing protocol contains resolutions to two problems. First, the distance from the candidate node to the BS has to be the most reasonable. Second, the remaining energy of a candidate node that wants to be a CH has to be greater than the average remaining energy level of live nodes in the WSN.

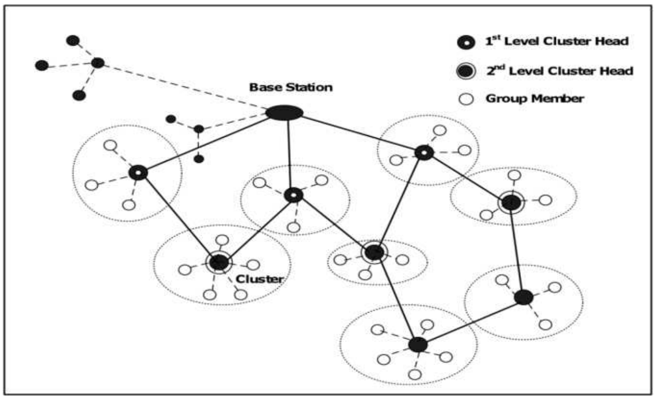

Figure 1: Cluster-based Model

II. LITERATURE REVIEW

The wireless sensor network has been deployed with different wireless networking technologies. The 802.11 protocol is the first standard protocol for wireless local area networks (WLAN), which was introduced in 1997.After that it was upgraded to 802.11b with data rate increased and CSMA/CA mechanism for medium access control (MAC). In 1998 this team developed second generation sensor node by applying some innovations which was named as Wireless Integrated Network Sensors (WINS). These WINS had a processor board with an Intel strong ARM SA1100 32-bit embedded processor (1 MB SRAM and 4 MB flash memory), radio board that supports 100 kbps with adjustable power consumption from 1 to 100 m, a power supply board, and sensor board.

Node first senses its target and then sends the relevant information to its cluster-head. Then the cluster head aggregates and compresses the information received from all the nodes and sends it to the base station. The nodes chosen as the cluster head drain out more energy as compared to the other nodes as it is required to send data to the base station which may be far located. Hence LEACH uses random rotation of the nodes required to be the cluster-heads to evenly distribute energy consumption in the network. After a number of simulations by the author, it was found that only 5 percent of the total number of nodes needs to act as the cluster-heads. TDMA/CDMA MAC is used to reduce inter-cluster and intra-cluster collisions. This protocol is used were a constant monitoring by the sensor nodes are required as data collection is centralized (at the base station) and is performed periodically.

In WSN, Sensor nodes sense the data from impossibly accessible area, cooperatively forward the sensed data to the sink or base station via multi-hop wireless communication and send their report to the base station also called the sink [10]. The nodes in wireless sensor networks can be mobile or stationary and deployed in the area through a proper or random deployment mechanism.

TL-LEACH (Two-Level Hierarchy LEACH)[1] is a proposed extension to the LEACH algorithm. It has two levels of cluster heads (primary and secondary) instead of a single one. Here, the primary cluster head in each cluster communicates with the secondary cluster head, and the corresponding secondary cluster head in turn communicate with the nodes in their sub-cluster. Data fusion can also be performed here as in LEACH. In addition to it, communication within a cluster is still scheduled using TDMA time-slots. The organization of a round will consist of first selecting the primary and secondary cluster heads using the same mechanism as LEACH, with the a priori probability of being elevated to a primary cluster head less than that of a secondary node. Communication of data from source node to sink is achieved in two steps: Secondary nodes collect data from nodes in their respective clusters. Data fusion can be performed at this level. Primary nodes collect data from their respective secondary clusters. Data-fusion can also be implemented at the primary cluster head level. The two- level structure of TL-LEACH reduces the amount of nodes that need to transmit to the base station, effectively reducing the total energy usage. LCTS (Local Clustering and Threshold Sensitive) [12]: It combines the advantages of LEACH and TEEN [11] in terms of short transmission delay and threshold based data gathering. The base station does cluster-head selection. LS-LEACH (Lightweight Secure LEACH) [13] is improved secure and more energy efficient routing protocol Authentication algorithm is integrated to assure data integrity, authenticity and availability. Furthermore, it shows the improvement over LEACH protocol that makes it secure and how to make it more energy efficient to reduce the effect of the overhead energy consumption from the added security measures. It provides security measures to LEACH protocol after indicating the source and limitation of nodes. Also, we develop security measures to protect wireless sensors and the communications from possible attacks without compromising the network performance. For instance, securing LEACH protocol against denial of service attacks while maintaining its performance. Furthermore, the protocol assures that only the authenticated nodes are allowed to join and communicated in the network. At the other hand, we mitigate the overhead cost from the security measures applied to avoid compromising the network performance. Sec-LEACH [14] proposes some creative modifications to LEACH protocol. It shows how to invest the key pre distribution scheme to secure node-to-CH communications. The main idea is to generate a large pool of keys and their IDs at the time the network is deployed, and then each node is assigned a group of these keys randomly. Also each node is assigned with a pair-wise key, which shares with the BS; these keys are used during node-node and node-Base Station communications. This algorithm provides authenticity, confidentiality, and freshness for node-to-node communication. The number of nodes does not impact the security level; actually it depends on the size of the key group assigned for each node according to the total size of the key pool [14].

III. CLUSTERING

In WSNs the sensor nodes are often grouped into individual disjoint sets called a cluster, clustering is used in WSNs, as it provides network scalability, resource sharing and efficient use of constrained resources that gives network topology stability and energy saving attributes. Clustering schemes offer reduced communication overheads, and efficient resource allocations thus decreasing the overall energy consumption and reducing the interferences among sensor nodes. A sensor node can scalable by assembling the sensor nodes into groups i.e. clust ers. Every cluster has a leader, often referred to as the cluster head (CH). A CH may be elected by the sensors in a cluster or pre assigned by the network designer. The cluster membership may be fixed or variable. WSN is large scale networks of small embedded devices, each with sensing, computation and communication capabilities. They have been widely discussed in recent years. A number of clustering algorithms have been specifically designed for WSNs for scalability and efficient communication. The concept of cluster based routing is also utilized to perform energy efficient routing in WSNs. In a hierarchical architecture, higher energy nodes (cluster heads) can be used to process and send the information while low energy nodes can be used to perform the sensing.

A large number of clusters will congest the area with small size clusters and a very small number of clusters will exhaust the cluster head with large amount of messages transmitted from cluster members. LEACH protocol is hierarchical routing based on clustering and find the optimal number of clusters in WSNs in order to save energy and enhance network lifetime.

We are given some clustering Advantages:

1. Clustering reduces the size of the routing table stored at the individual nodes by localizing the route set up within the cluster.
2. Clustering can conserve communication bandwidth since it limits the scope of inter cluster interactions to CHs and avoids redundant exchange of messages among sensor nodes.
3. The CH can prolong the battery life of the individual sensors and the network lifetime as well by implementing optimized management strategies.
4. Clustering cuts on topology maintenance overhead. Sensors would care only for connecting with their CHs.
5. A CH can perform data aggregation in its cluster and decrease the number of redundant packets.
6. A CH can reduce the rate of energy consumption by scheduling activities in the cluster.

IV. LEACH PROTOCOL

Low-Energy Adaptive Clustering Hierarchy (LEACH) [15] [16] is one of the clustering based hierarchical routing protocols. It is used to collect data from wireless network. In the network, hundreds/thousands of wireless sensors are dispersed that collects and transmit data. In these sensor nodes the cluster head's are elected. Because sensor nodes have low energy source and battery cannot be replaced once deployed, the chances of node death scenario is more. So we require LEACH protocol to increase the lifetime of network. LEACH protocol uses random selection cluster head selection and cluster formation. Here the energy is evenly distributed by rotating the cluster head in every round. LEACH protocol is divided into 2 phases:

1) Set-Up phase: Set-up phase includes cluster head selection and cluster formation. Cluster head selection algorithm: In this phase, the nodes are randomly dispersed in a network. Each node takes a self-governing decision whether to become a cluster head for current round or not. Here every node will generate a random number between 0 and 1. If the number is less than threshold value, then node is cluster head for the current round. Threshold is given by

$$T(n) = \frac{P}{1-P\left(r \bmod \frac{1}{P}\right)} \; if \; n\epsilon G \quad (1)$$

In the above equation (1), the parameters are: p - optimal percentage of CHs in each round. r - current round. G - is set of nodes, which have not been elected as CH in (1/p) rounds. Cluster formation: After cluster head selection, each node broadcasts advertisement (ADV) message using (CSMA/CA) MAC protocol. The near-by nodes send join request to cluster head. It follows a TDMA schedule to setup and transmission and to assign separate time slots to each of its cluster members

2) Steady-state phase: This phase consists of transmitting data from cluster members to cluster head during allotted time slots. The cluster head aggregates data and forwards to base station.

LEACH algorithm has the following Advantages:

- The hierarchy, routing information and path selection are relatively simple, and the SNs do not need to store large amounts of routing information, and do not need complex functions. The CH node is randomly selected, the opportunity of each node is equal, and the load of whole network is balance [17]. However, there are a number of disadvantages in LEACH protocol, such as:
- Because the CHs in LEACH protocol are randomly generated, energy consumption can be evenly distributed in the network. However, it does not consider residual energy of sensor nodes. Therefore, it is possible for a sensor node that has low residual energy to be selected as a CH. This can render the cluster useless due to the quickly exhausted battery power of the CH.
- On the other hand, LEACH does not examine the distance between sensor nodes and the BS. Consequently, if the geographic position of the CH is far from the BS and the geographic position of the CM is far from their CH, it will consume a lot of energy sending and forwarding data. So it can easily lead to exhaust the energy quickly in sensor nodes [17].

The LEACH Network is made up of nodes, some of which are called cluster-heads .The job of the cluster-head is to collect data from their surrounding nodes and pass it on to the base station. LEACH is dynamic because the job of cluster-head rotates.

Cluster-heads can be chosen stochastically (randomly based) on this algorithm:

$$T(n) = \frac{P}{1 - p \times (r \bmod p^{-1})} \quad \forall n\epsilon G$$

$$T(n) = 0 \quad \forall n\epsilon G$$

Where n is a random number between 0 and 1

P is the cluster-head probability and

G is the set of nodes that weren't cluster-heads the previous rounds

If n < T(n), then that node becomes a cluster-head . The algorithm is designed so that each node becomes a cluster-head at least once.

Cluster Head selection Algorithm Pi(t) is the probability with which node I elects itself to be Cluster Head at the beginning of the round r+1 (which starts at time t) such that expected number of cluster-head nodes for this round is k.

$$E[\#CH] = \sum_{i=1}^{N} P_i(t) * 1 = k.$$

k = number of clusters during each round. N = number of nodes in the network. Each node will be Cluster Head once in N/k rounds (Round #1,2,3 … Round #N/K, then Round #1, #2, …). – N/K also means cluster size. In each cluster, each sensor has equal chance to become CH. Probability for each node I to be a cluster-head at time

$$P_i(t) = \begin{cases} \dfrac{k}{N - k * \left(r \bmod \frac{N}{k}\right)} & : \; C_i(t) = 1 \\ 0 & : \; C_i(t) = 0 \end{cases}$$

$\sum_{i=1}^{N} C_i(t)$ total no. of nodes eligible to be a cluster head at time t This ensures energy at each node to be 2pprox. Equal after every N/k rounds.

$$E[\#CH] = \sum_{i=1}^{N} P_i(t) * 1$$

$$= \left(N - k * \left(r \bmod \frac{N}{k}\right)\right) * \frac{k}{N - k * (r \bmod \frac{N}{k})} = K$$

Cluster Formation Algorithm:

1. Cluster Heads broadcasts an advertisement message (ADV) using CSMA MAC protocol. ADV = node's ID + distinguishable header.
2. Based on the received signal strength of ADV message, each non-Cluster Head node determines its Cluster Head for this round (random selection with obstacle).
3. Each non-Cluster Head transmits a join-request message (Join-REQ) back to its chosen Cluster Head using a CSMA MAC protocol. Join-REQ = node's ID + cluster-head ID + header.
4. Cluster Head node sets up a TDMA schedule for data transmission coordination within the cluster.
5. TDMA Schedule prevents collision among data messages and energy conservation in non cluster-head nodes.

V. DBEA_LEACH

In second proposal, which we call DBEA-LEACH, in order to select the appropriate CH nodes in the CH nodes selection phase, DBEA-LEACH algorithm takes important factors such as position of the sensor node relative to the BS and the amount of residual energy of each sensor node. Similar to DB-LEACH, DBEA-LEACH establishes a new threshold based on distance. In addition, it introduces current energy and initial energy of the node to CH election probability so as to ensure these nodes with higher remaining energy have greater probability to become CHs than that with the low remaining energy. The CH nodes selection directly affects the performance factors of WSN such as load distribution, energy efficiency, and network lifetime.

$$T(n) = \begin{cases} C \times \dfrac{|d_{toBSavg} - d(i,BS)|}{d_{toBSavg}} \times \dfrac{E_i}{E_{init}}, \; if \; n \epsilon G \\ 0 \end{cases} \quad (4)$$

Here, E_i is the residual energy of candidate node i at the current round. E_{inital} denotes as the initial energy of the node before the transmission. Equation (4) shows that the threshold value depends on the geographical distance between sensor node and the BS and the residual energy of the candidate node.

VI. PROPOSED METHOD

A new approach using LEACH is proposed which focus on lifetime maximization as well as on Quality of Service (Qos). The performance of WSN depends upon many parameters but lifetime maximization is important aspect of any network. In proposed method for improving lifetime anQos, two parameters are chosen i.e. FND (first node die) time and cluster head selection probability. In this protocol the selection process for Cluster head depends not only on maximum energy content of the node in the same cluster after each round but also concerned with probability to become cluster. After every round of transmission the energy level of each node will be different and the cluster head will be changed accordingly. The node which will become cluster head in the beginning will alive for longer duration. The quality of service of the network will also improve as the large number of node will remain alive till end. Cluster head is selected randomly in the beginning. Base station is continuously monitoring the energy level of all the nodes. After completion of a round, the energy level of nodes will vary. The node with highest energy level in that particular cluster will automatically become Cluster Head. Adopting this approach the energy level of nodes will not decay in rapid trend, ultimately increasing the first node die time which will enhance the lifetime as well as Quality of Service. Significance is given to node with highest residual energy after each epoch.

The demand for maximum network lifetime in many mission-critical applications of wireless sensor networks motivates the great significance to deploy as few sensors as possible to achieve the expected network performance. Proposed system use a deployment strategy with T as the required minimum network lifetime. In order to achieve evenly balanced energy consumption among all nodes, the node density in different areas of the network should be a continuous varying function of the distance from the sink.

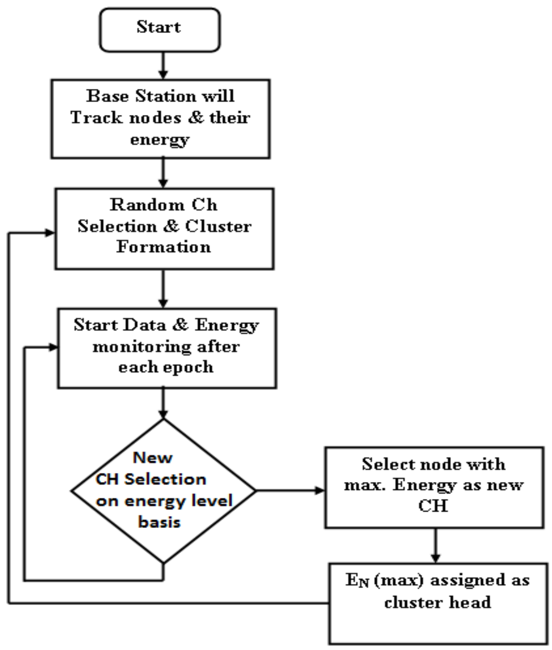

Figure 2: Flow chart of proposed modified LEACH

The Flow chart of Priority LEACH is shown in Figure-2. Subsequently first round of transmission, the level of energy of Cluster Head is compared with the energy of remaining nodes in the cluster. Selecting the higher energy node as new CH, if energy of current CH is higher, the same cluster head will carry on the operation otherwise new cluster head will be formed.

VII. COOPERATIVE RELAY SYSTEM

In this subsection we intend to solve the stopping problem discussed above by deriving an optimal rule that decides when to stop observing the candidate relays. Now we derive the optimal stopping rule as the solution to the stopping problem. We formulate our solution approach as a backward induction. The maximum return that the PU transmitter can obtain after obtaining j_{th} candidate relay is denoted by $V_j^{(M)}(x_1,x_2,\dots x_j)$, given by

$$V_j^{(M)}(x_1,x_2,\dots x_j) = \max\left\{y_j(x_1,x_2,\dots x_j),\ E\left\{V_{j+1}^{(M)}(x_1,x_2,\dots x_{j+1}) \times |X_1 = x_1,\ X_2 = x_2,\dots,X_j = x_j\right\}\right\} \quad (1)$$

Where $y_j(x_1,x_2,\dots,x_j)$

Represent the instantaneous reward after k_{th} observation, and $E\{V_{j+1}^{(M)}|X_1 = x_1,\ X_2 = x_2,\dots,X_j = x_j$ represents the expected reward achieved by skipping to observe next SU relay.

When $V_j^{(M)}(x_1,x_2,\dots x_j) = y_j(x_1,x_2,\dots x_j)$, it is optimal to stop scanning the relays. The optimal stopping rule is achieved when the following condition is satisfied

$$y_j(x_1,x_2,\dots x_j) > \left\{E\left\{V_{j+1}^{(M)}(x_1,x_2,\dots x_{j+1}) \times |X_1 = x_1,\ X_2 = x_2,\dots,X_j = x_j\right\}\right\} \quad (2)$$

Backward induction is clearly understood when the expected reward, $E\{V_{j+1}^{(M)}\}$ is defined as Z_{M-j}, if PU pair proceed to scan next SU relay which is given by

$$Z_{M-j} = E\left\{V_{j+1}^{(M)}(x_1,x_2,\dots x_{j+1}) \times |X_1 = x_1,\ X_2 = x_2,\dots,X_j = x_j\right\} \quad (3)$$

The set $\{X_1, X_2, \dots X_M\}$ for SU candidate relays are mutually independent. Thus Z_{M-j} is a constant that only depend on M-j, the number of remaining steps to continue.

Optimal stopping rule is as follows. PU pair observes candidate relays based on observation sequence S and obtain instantaneous reward y_k after k_{th} observation. Then the value of y_k with the value of Z_{M-k} is compared and decide to stop at k_{th} step if $y_k > Z_{M-k}$ and to continue observing next relay otherwise. If the PU pair observe the last relay in the observation sequence and the condition is not satisfied and it is forced to take that last relay in the sequence as cooperative relay. This is called worst case relay selection. If the PU pair stops and selects a suitable cooperative relay more quickly when observing the SU candidate relays based on an observation order denoted by S1 compared with another observation order denoted by S2,say that the order S1 is more efficient than the order S2.

First, consider a random observation order strategy in which the PU pair constructs the observation sequence randomly at every time slot. Since the observation variable set $\{X_1, X_2, \dots, X_M\}$ is independent for each time slot, the efficiency of this order strategy is uncontrollable. Due to the poor performance of the random observation order strategy, take into consideration an intuitive order.

Construct the observation sequence $S = \{s_1, s_2, \cdots, s_M\}$;
Start observation for a cooperative relay from s_1;
for $k \leftarrow 1$ to $M-1$ **do**
    Compute the achievable transmission rate r_k after the k^{th} observation and the reward y_k given by (7);
    Compare the value of y_k and the expected reward Z_{M-k} given by (11);
    if $y_k < Z_{M-k}$ **then**
        Proceed to observe the next SU candidate relay;
    else
        Stop at the current step and select the k^{th} SU node as the cooperative relay;
    end if
end for
Select the M^{th} SU node s_M as the cooperative relay;

VIII. RESULTS

The algorithm was implemented in MATLAB simulation tool. The toolbox of MATLAB 7.10.0 is used for simulation of graphical comparison. In order to evaluation of proposed algorithm (DBEA-LEACH), the algorithms with the similar basic idea are selected. The LEACH algorithm as the basis of cluster-based routing algorithm is selected in order to compare with two proposed algorithm.

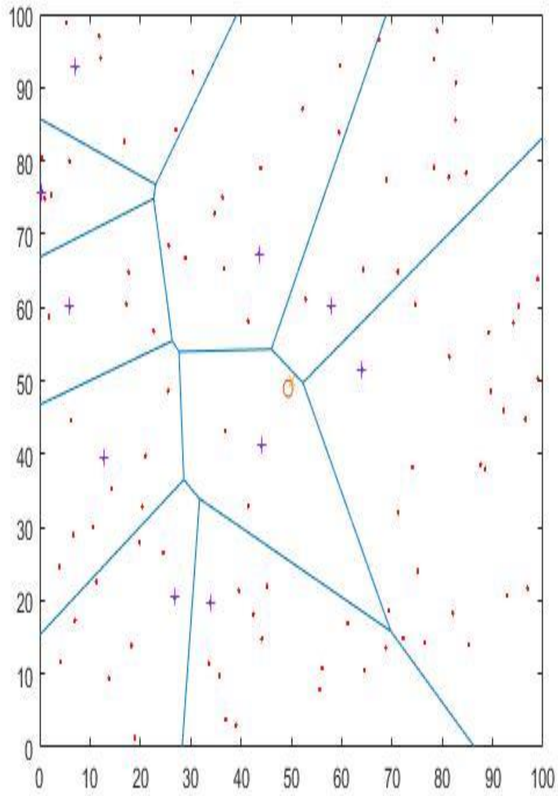

Figure 4 Number of Active and Passive Nodes

FDT-LEACH and DBEA-LEACH perform, where Stability period is the time when death of the first node occurs. This time is also known as first node death time (FDT) of LEACH occurs at 2196th second. DBEA-LEACH, in order to select the appropriate CH nodes in the CH nodes selection phase, DBEA-LEACH algorithm takes important factors such as position of the sensor node relative to the BS and the amount of residual energy of each sensor node. Figure 5 shows the comparison of average energy of each routing protocols calculate as o to 250 round numbers. In evaluation metrics, we assumed that initial energy per node is 0.1J (total 100 node is 10J).

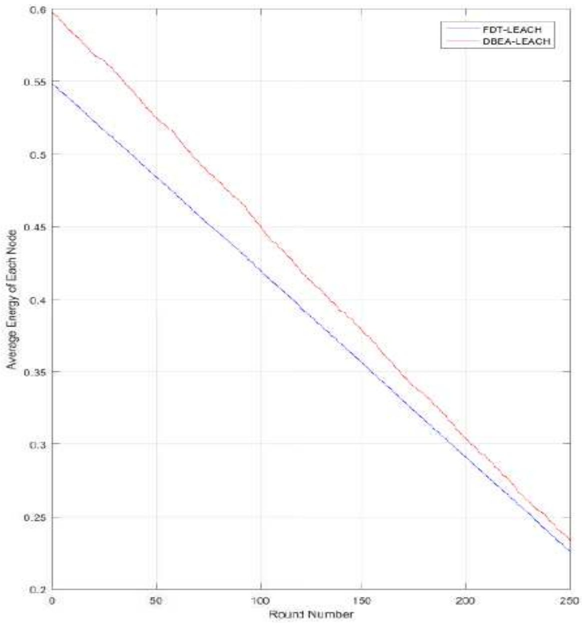

Figure 5 Average Energy Node vs Round Number (0 to 250)

Figure 6 shows the comparison of average energy of each routing protocols calculate as 0 to 500 round numbers. In evaluation metrics, we assumed that initial energy per node is 0.1J (total 100 node is 10J).

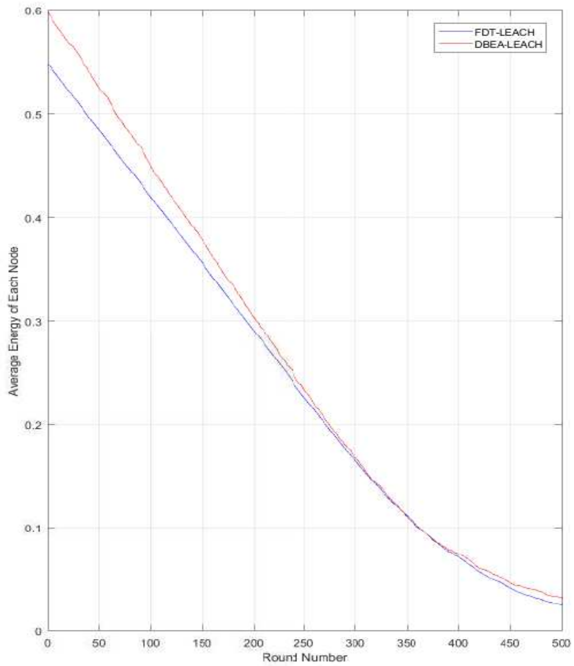

Figure 6 Average Energy Node vs. Round Number (0 to 500)

Figure 7 shows the comparison of average energy of each routing protocols calculate as 0 to 800 round numbers. In evaluation metrics, we assumed that initial energy per node is 0.1J (total 100 node is 10J).

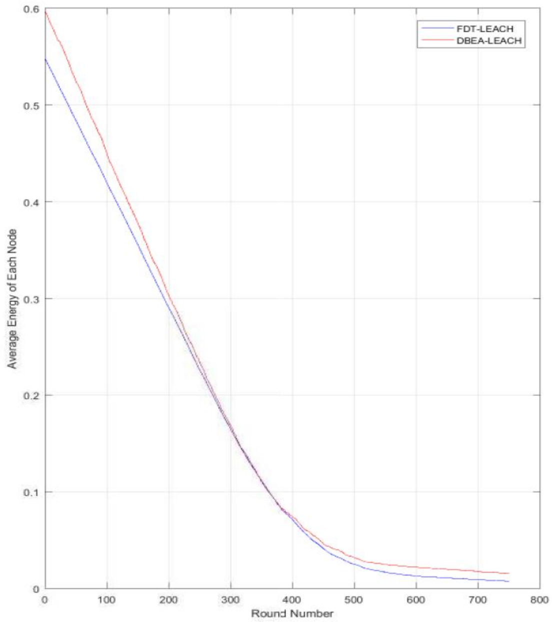

Figure 7 Average Energy Node vs. Round Number (0 to 800)

Figure 8 shows the comparison of average energy of each routing protocols calculate as 0 to 1000 round numbers. In evaluation metrics, we assumed that initial energy per node is 0.1J (total 100 node is 10J).

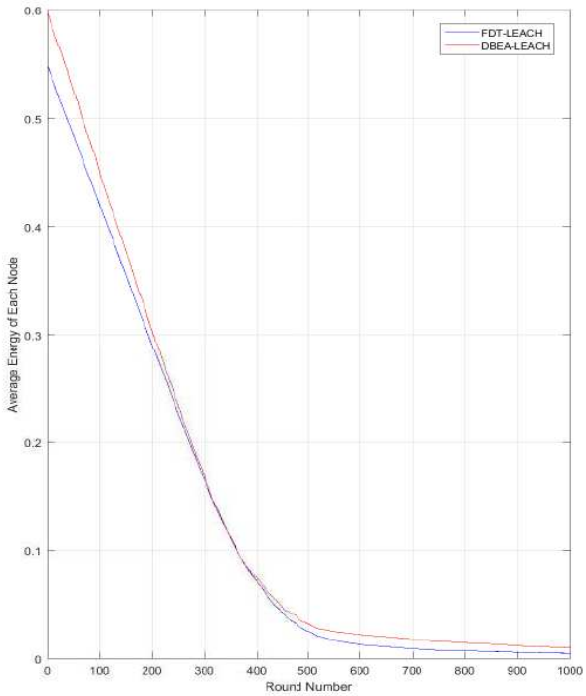

Figure 8 Average Energy Node vs. Round Number (0 to 1000)

DBEA-LEACH has low number of dead nodes than LEACH. In addition, DBEA-LEACH protocol has the lowest number of dead nodes compared with other protocols. DBEA-LEACH has less number of dead nodes in per round, because DBEA-LEACH selects a cluster head not only based on distance, but also by examining residual energy of the node greater than the average residual energy level of nodes in network so as to ensure these nodes with higher remaining energy have greater probability to become CHs than that with the low remaining energy. The CH selection of DBEA LEACH can more uniform distribution between the nodes and avoids making early death of sensor nodes. Figure 9 shows red and blue lines how much number of dead nodes.

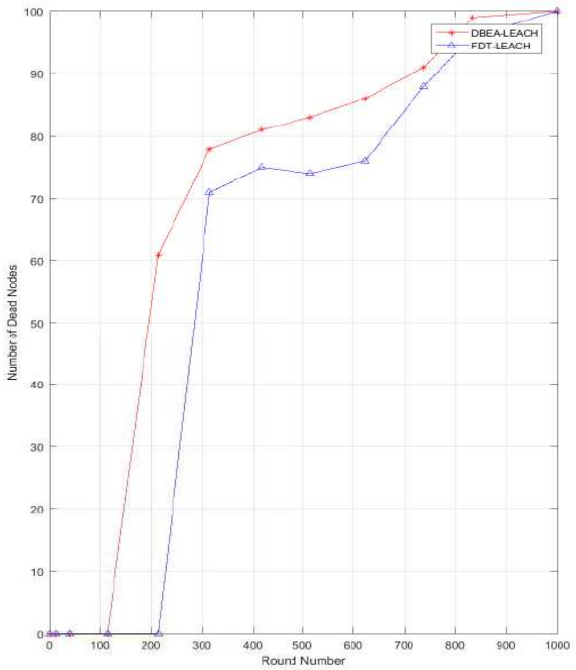

Figure 9 Numbers of Dead Nodes

Jitter is defined as a variation in the delay of received packets. The sending side transmits packets in a continuous stream and spaces them evenly apart. Average jitter is packets sent to the base station. In figure 10 shows average jitter with BDEA-LEACH and FDT LEACH.

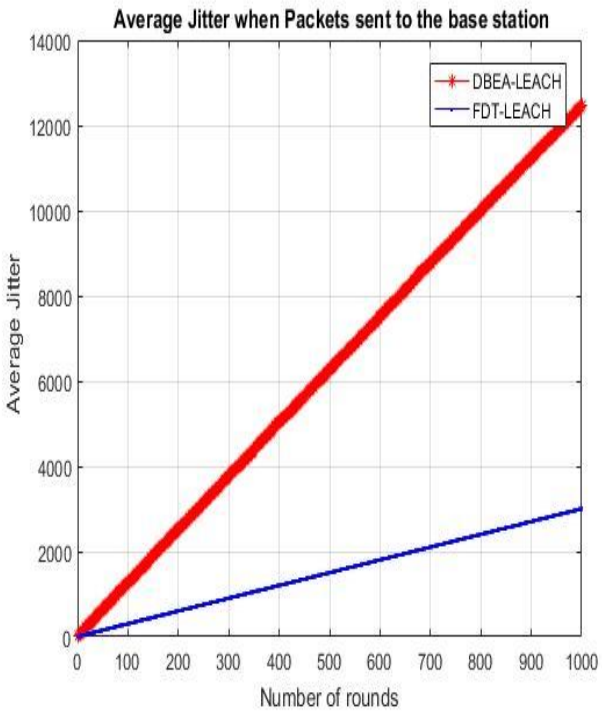

Figure 10 Average Jitter

End to End Delay is the time taken for a packet to be transmitted across a network from source to destination. In figure 11 shows end to end delay using DBEA-LEACH and FDT-LEACH.

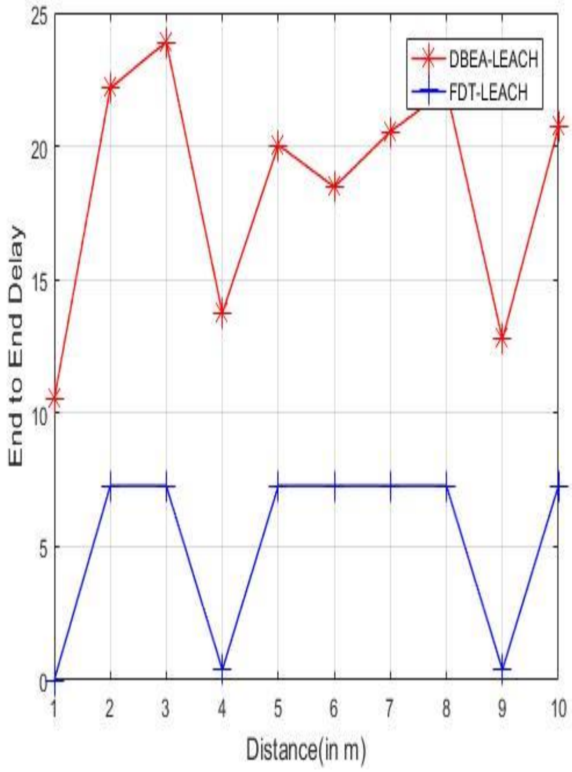

Figure 11 End to End Delays

Figure 12 shows routing Packets overhead with BDEA-LEACH and FDT-LEACH.

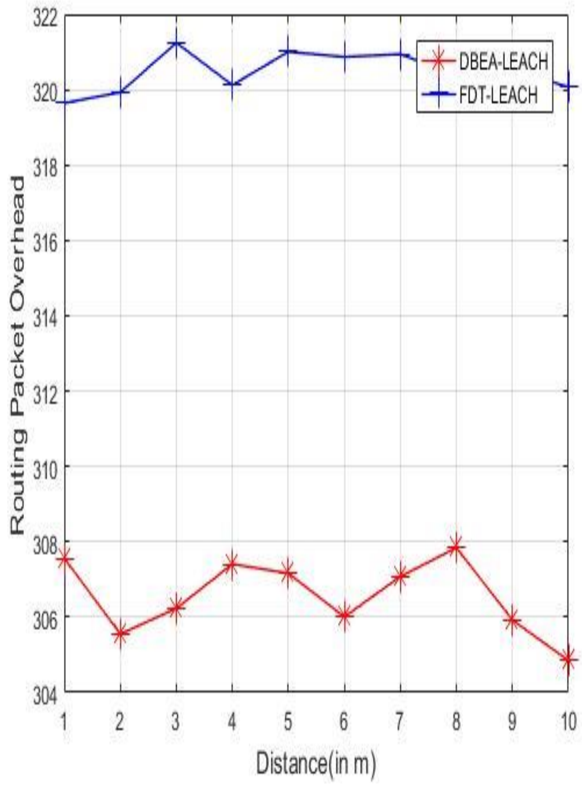

Figure 12 Routing Packets Overhead

IX. CONCLUSION

The results of this paper show improvement in energy efficiency, throughput, less packet drops and packet delivery ratio when compared to LEACH. This paper is compared with other two protocols DBEA-LEACH and FDT-LEACH. The proposed hierarchical routing protocol increases the number of packets received at the sink by adapting the technique of dynamic clustering with dynamic selection of cluster-heads at first round and static clustering with dynamic selection of cluster heads from second round. The cluster-head selected in consequent rounds is decided based on the residual energy and distance to the base station. Simulation results show that, this algorithm is much more efficient then other algorithms.

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