

Improvement of Energy efficient leach protocol in WSN

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Abstract - Wireless Sensor Network (WSN) consists of a large number of tiny devices called sensor nodes, which are usually deployed randomly over a wide area in order to sense and monitor various physical phenomena related parameters including environmental conditions at various locations. The WSN nodes communicate with each other. One of the efficient WSNs protocol is Low Energy Adaptive Cluster Hierarchy (LEACH). In this paper we present leach protocol and we use heterogeneous nodes for data transmission through the optimal path between cluster heads (CHs) and the base station (BS). In LEACH, Non-Cluster head Nodes decide to link a cluster head based on Received Signal Strength (RSS) of receiving packets from CHs. LEACH protocol and improved LEACH and multi-level LEACH protocols like MLEACH protocol, DD-LEACH protocol and TL-LEACH protocol is compared. Classical clustering protocols assume that all the nodes are equipped with the same amount of energy and as a result, they cannot take full advantage of the presence of node heterogeneity. The main purpose is to improve the network lifetime and particularly the stability period of the network.

Index Terms - Wireless sensor network (WSN), LEACH protocol, clustering protocol

I. INTRODUCTION

Wireless Sensor Networks (WSNs) (1) are networks of light-weight sensors that are battery powered consumed majorly for monitoring purposes. WSNs are growing equipped to handle some of these complex functions, in-network processing such as data aggregation, information fusion, computation and transmission activities requires these sensors to consume their energy efficiently in order to extend their effective network life time. Sensor nodes are ready to energy drainage and failure, and their battery source might be irreplaceable, instead new sensors are deployed. Thus, the stable re-energizing of wireless sensor network as old sensor nodes die out and/or the uneven terrain of the scope being sensed can lead to energy imbalances or heterogeneity among the sensor nodes. . The nodes consist of the sensor module which senses the environment, the processor and memory which perform local computation on the sensed data and store data, the transceiver responsible for exchange information with neighbor nodes and a power supply unit for node's energy. This node architecture is shown in Figure 1.1.

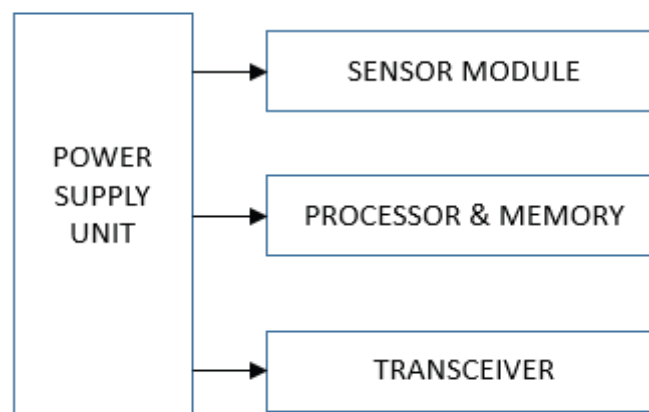


Figure 1.1: Node architecture

Sensor networks (2) refers to a heterogeneous channel consisting of multiple detection stations called sensor nodes with a communications infrastructure studied to monitor and record conditions at diverse locations. Sensor nodes, also known as point, are small, lightweight and portable devices equipped with a transducer, microcomputer, transceiver, and power source. The transducer generates electrical signals based on the sensed physical phenomena. The microcomputer processes and stores the sensed information. The transceiver gets instructions from the base station/central computing system and dispatch data to it. Each sensor nodes derives its energy usually from a battery or any other embedded form of energy harvesting. The size of the sensor

nodes change from that of a shoe box to that of a minute sand particle. Similarly their expense also varies from hundreds of dollars to a few pennies. Size and cost impact result in corresponding constraints on energy, memory, computational speed and communications bandwidth.

II. LEACH ROUTING PROTOCOL

LEACH (3) is a hierarchical routing protocols used in WSNs to enlargement the network lifetime LEACH is a clustering, adaptive, and self-organizing protocol. LEACH assumes that the base station is fixed and located far from the sensor nodes. Additionally, all sensor nodes are homogeneous and have limited energy and memory. Sensors can communicate among each other and also they can communicate directly with the BS. The main idea of LEACH protocol is to organize the nodes into clusters to distribute the energy among all nodes in the network. Also, in each cluster there is a node called a cluster head (CH). This CH will aggregate the data received from sensors within its cluster and forward them to the BS. Figure 2.1 shows LEACH routing protocol.

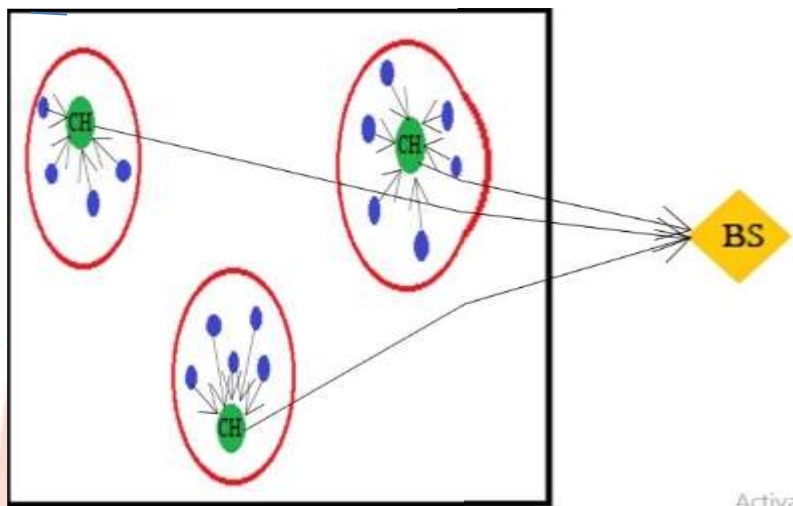


Figure 2.1: Leach routing protocol

LEACH (3) is already established as a promising protocol in wireless sensor networks domain, still there are some areas for improvement to make the protocol more efficient. In this we present a modification on LEACH's cluster head election algorithm to reduce and make balance the total energy dissipation of the sensors. Our sensor network model has the following properties:

- The sensor nodes are of homogeneous type.
- All the sensor nodes are with uniform initial energy allocation.
- The nodes are eligible to determine its current energy level.
- All the sensor nodes are immobile.
- Nodes do not have location information.
- Data aggregation is done at the cluster head only.
- The fixed base station is far away from the sensor nodes.
- The communication channel is symmetric

III. Existing techniques of LEACH protocol

To overcome limitations of the LEACH (4), some improvements have been incorporated into the LEACH protocol. Few improved routing protocols are: TL-LEACH, M-LEACH and DD-LEACH. These are hierarchical and more advanced over LEACH protocol, dissipate less energy as compared to LEACH and provide prolonged lifetime. All these improved protocols use clustering. Clustering has an advantage over other algorithms due to following reasons: minimization of energy consumption of intra-cluster as well as inter-cluster network, scalability of the network, prolonged network life time, reduction in information packet delay, and handling heterogeneity in the network.

3.1 Two-Level LEACH (TL-LEACH) Protocol

TL-LEACH protocol (4) is an advanced version of the LEACH protocol. In LEACH protocol, a CH sends the aggregated data to the BS directly. Due to this process, CH may die soon as compared to the other nodes, especially when the CH is quite distant from the BS. To circumvent this, TL-LEACH has been used. Here, we have two levels of CHs. The CH selection process remains same as that of the LEACH. During setup phase, we select 1-level CH and then 2-level CH. The 2-level CHs are selected among the 1-level CHs. Then the CHs broadcast to the other nodes that they are the CHs and the same process goes on as in LEACH. In steady state phase, the data packets transmitted by nodes are received by 1-level CH, which are

forwarded to the 2-level CH, and finally send to the Figure 3.1 illustrates TL-LEACH protocol. This protocol can support large networks with extended network life time.

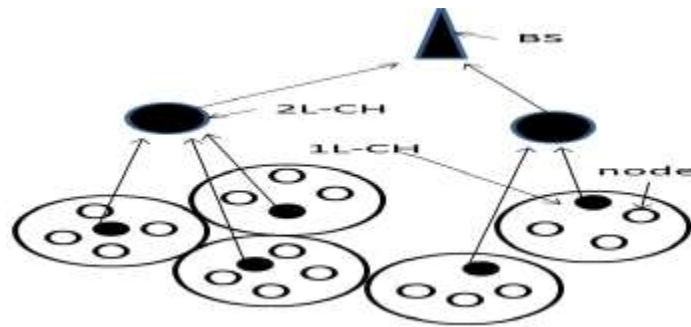


Figure 3.1: TL-LEACH protocol process

3.2 Multi-hop LEACH (M-LEACH) Protocol

In LEACH protocol (4) each CH sends the aggregated data to the BS directly. Some of the CHs may not be able to reach the BS directly due to limited transmit range. To circumvent such a situation, using multi-hop LEACH (M-LEACH), a CH can make use of one of its neighbouring CH nodes towards the BS as a relay node to forward its aggregated data. In the similar manner, a multi-hop communication path could be established so as to forward the data of a distant CH. All the relay nodes involved are CHs themselves. The setup phase of M-LEACH is same as that of LEACH. In M-LEACH, CHs are selected first, and these CHs then send broadcast messages that they are the CHs to the nodes. Then nodes identify the cluster to which they belong. All CHs broadcast TDMA schedule to the nodes in their clusters. After getting the TDMA schedule, the nodes are ready to send data to their CH. Hence nodes forward the data to its CH, and the data sent to the CH will reach the BS in multi-hop pattern. The CH will not send the packet directly to the BS, but to its neighbouring CH toward the BS. The neighbouring CH then forwards the packet to other neighbouring CHs, headed towards BS. Figure 3.2 shows M-LEACH protocol data transfer. Similarly, other rounds of CH selection take place and the whole process continues for multiple rounds. This protocol extends the network lifetime since CH drains less energy as compared to that of TL-LEACH protocol.

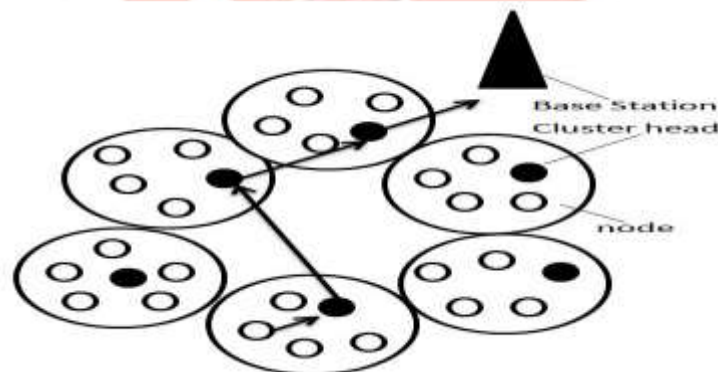


Figure 3.2: M-LEACH protocol process

3.3 DD-LEACH protocol

It is a combination of LEACH (4), a hierarchical based protocol and directed diffusion, a data-centric dissemination protocol. It supports two levels. At the first level, LEACH model is used and at the second level, directed diffusion model adopted. As in LEACH protocol, cluster formation is done, CH is selected over a cluster and TDMA schedule is distributed among nodes by CH. After undergoing setup and steady state phases, the BS broadcasts the query to the nearby CHs and those CHs in turn pass the query to other CHs. Hence the interest is communicated among all the CHs. The CHs act on the bases of the query received and forward the data to the BS. The CH forms a gradient with a nearby CH in order to communicate to the BS. The CH does not send data directly to the BS but through the reinforced path. The CH forwards only the aggregated query related data. Hence, considerable energy is conserved, and also due to the fact that the CHs are not communicating to the BS directly.

3.4 LEACH-C Protocol

LEACH-C (5) is also a cluster based protocol that uses a centralized clustering algorithm. The clusters are formed by the BS. Each node sends information about its current location and energy level to the BS. The BS computes the average node energy, and whichever nodes have energy below this average cannot be cluster-heads for the current round. Using the remaining nodes as possible cluster-heads, the BS finds clusters using the simulated annealing algorithm to solve the NP-hard problem of finding k optimal clusters. This algorithm attempts to minimize the amount of energy for the non-cluster head nodes to transmit their data to the cluster head, by minimizing the total sum of square distances between all the non-cluster head nodes and the closest cluster-head. Eventually, the BS broadcasts a message that contains the cluster-head ID for each node. The steady-state phase of LEACH-C is identical to that of LEACH. The problem with LEACH and LEACH-C is that it assumes that cluster-

heads are uniformly distributed. The main concept behind this protocol is that by using a centralized control algorithm better clusters can be formed by dispersing the cluster heads on the basis of their geographical location throughout the WSN. That is the basic concept for LEACH-centralized (LEACH-C) as shown in Figure 3.3. All nodes send information about their location (using a GPS receiver) and their amount of energy left to the BS, during LEACH-C's setup phase. In addition to making ideal clusters for the WSN, the BS needs to make sure that all nodes distribute energy evenly among themselves.

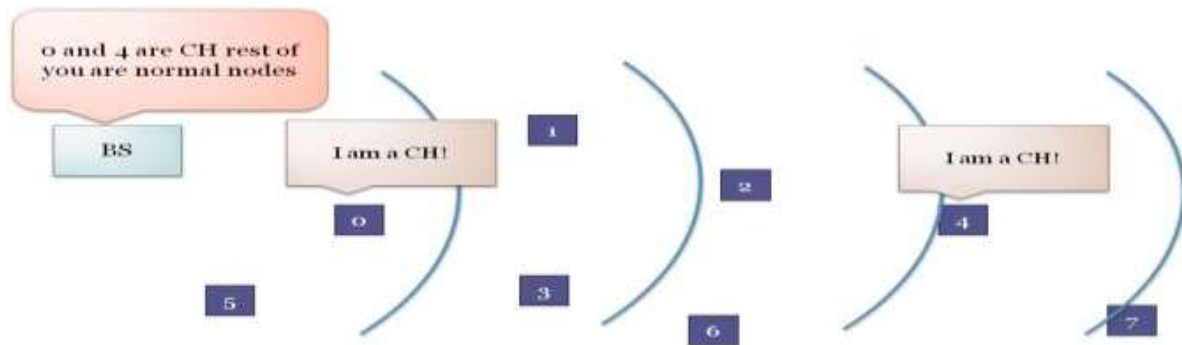


Figure 3.3: LEACH-C Architecture

3.5 WEEC Protocol

WEEC (5) is an improvement on LEACH protocol that takes the location of each node into consideration while clusters are forming. The probability of each node to be cluster-head is reliant on its distance and total distances of all nodes to the BS. As follows, the probability of selecting the furthest node in a region to the BS is the lowest, while the probability of selecting the closest node to the BS is the highest. After assigning a probability to each node, each node selects a random number between 0 and 1 in each round and compares the selected random number to its assigned probability. If the random number is less than the assigned probability, the node would be selected as a cluster-head for the next round. The advantage of this protocol is that a desired number of cluster-heads is guaranteed. The main drawback of WEEC is to not consider the residual energy of each node during the cluster-head selection.

3.6 V-LEACH

The cluster contains (6) CH (responsible only for transmitting data that is received from the cluster members to the BS), vice-CH (the node that will turn out a CH of the cluster in case of CH dies), cluster nodes (gathering data from environment and dispatch it to the CH). In the original leach, the CH is always on receiving data from cluster members, aggregate these data and then dispatch it to the BS that might be located far away from it. The CH will expire earlier than another nodes in the cluster because of its operation of receiving, sending and overhearing. When the CH expires, the cluster will become unnecessary because the data gathered by cluster nodes will never reach the base station. In V-LEACH protocol, except having a CH in the cluster, there is a vice-CH that takes the role of the CH when the CH expires. The process of cluster head selection criteria is discontinuous. It is on the basis of three factors i.e. Minimum distance, maximum residual energy, and minimum energy. Based on received signal strength, each non-cluster head node determine its cluster head, greater the signal strength means shorter the distance between them and if distance is small then for the devolution less energy is required. The proposed approach will improve the network life as never the cluster head will expire. As a cluster head will expire it will be replaced by it's vice Cluster head. By doing this, cluster nodes data will always reach the BS; no need to option a new CH each time the CH dies. This will extend the overall network life time.

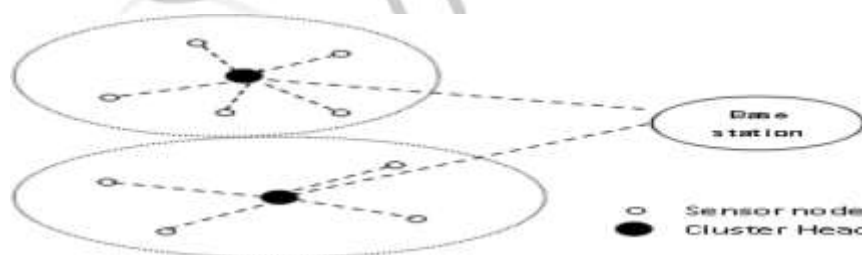


Figure 3.4: V LEACH Architecture

3.7 SLEACH

This is the first (6) modified secure version of LEACH called SLEACH, which investigated the problem of adding protection to cluster-based communication protocol for homogeneous wireless sensor networks consisting of sensor nodes with strongly limited resources. SLEACH provides protection in LEACH by using the building block of SPINS (Security Protocol for Sensor Network), symmetric-key methods and MAC (Message Authentication Code). SLEACH protects against selective forwarding, sinkhole and HELLO flooding attacks. It prevents intruder to send factitious sensor data to the CH and CH to forward phony message. But SLEACH Cannot prevent to crowd the time slot schedule of a cluster, causing DoS attack or merely lowering the throughput of the CH and does not guarantee data confidentiality. The solution is meant to protect only outsider attack.

3.8 RLEACH

Secure solution (6) for LEACH has been introduced called RLEACH in which cluster are formed dynamically and periodically. In RLEACH the orphan node problem is raised due to random pair-wise key scheme so they have applied improved random pair-wise key scheme to overcome. RLEACH has been used the one way hash chain, symmetric and asymmetric cryptography to endow protection in the LEACH Hierarchical routing protocol. RLEACH protect many attack like spoofed, alter and replayed information, sinkhole, worm-hole, selective forwarding, HELLO flooding and Sybil attack.

IV. Purposed Work

This paper presents a new version of LEACH protocol which basically relies on two main factors i.e. reliability in terms of all data packet delivery and energy efficiency. Although LEACH is best amongst all the routing protocol for WSN still it has some drawbacks. One of the main drawback is it has no optimal data aggregation technique and it provides no reliability in terms of all the packet are delivered to sink or not. Better data aggregation technique may reduce the overall energy dissipation for a cluster in LEACH as battery consumption is important fact to be taken in to consideration which is a scarce resource and can't replace further in the network after battery loss. Reliability is also a major necessity in data aggregation.

Pseudo-code of the proposed LEACH Protocol:

```

number of nodes (n),
r a random number lies between (0, 1),
Pset specify the probability;
Selection of CH and Formation of clusters
if (Etotal > 0 ) then
compute T(s); //given by (1)
if (r < T(s)) then
CH[i]=TRUE //node i be a CH
else
CH[i]=FALSE; //node i not be a CH
end if
end if
if (CH[i]=TRUE) then
Broadcast(Adv) //CH broadcast advertisement message
Join(IDi) // non-cluster head node i join nearest CH
cluster(c) //cluster is formed
end if
//this process repeats for multiple rounds
Query flow process and data transmission
if (CH2(i)=TRUE) then //if i is secondary CH
BStoCH2(query) //BS send query to secondary CH
if (CH1(i)=TRUE) then // if i is primary CH
CH2toCH1(query) //BS send query to primary CH
if (CH(i)=FALSE) then
CH1tonode(query) // primary CH send query to nodes
if (node[i]=sensed data) then
nodetoCH1(Data-pck) //node will send data to CH1
from which it receive the query
Aggregate(Data- pck) //CH1 aggregate received data
CH1toCH2(Data-pck) //node will send data to CH2
from which it receive the query
Aggregate(Data- pck) //CH2 aggregate received data
CH2toBS(Data-pck) //CH2 send back to BS
else sleep – state //node go to sleep state
end if

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V .Simulation Result

In this section, we will discuss the efficiency and performance of our purposed protocol. We take a 100m x 100m region for our network and total nodes are 90. We divided the area into three concentric rings having 20m, 35m and 50m radii and then made regions out of these three circles. We provided 10 nodes to individually region of our network. Some basic simulation parameters are given in Table 1.

Table 1: Parameters used in Simulations

Parameter	Value
Network size	100m x 100m

Initial energy of each node	0.5J
E_{TX}	50nJ
E_{RX}	50nJ
E_{DA}	5nJ
Maximum Radius of Circles	50
Packet size	4000 bits

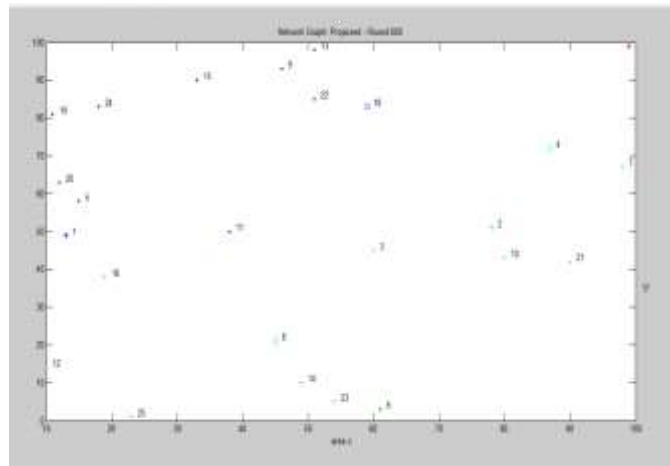


Fig.5. 1 Initialization of network consisting of 25 nodes

5.1 DEAD NODES

All Nodes remain alive until they have energy more than zero. LEACH uses its own probability function for clustering in the entire area and all nodes have the same probability to convert a CH, therefore, all nodes die linearly after the first node dies. Whereas using Direct Communication to the BS in its 1st region and all other regions usage clustering which is based upon extreme energy. It means the node which has extreme energy in its corresponding region will be selected as the CH, this technique confirms the energy efficiency of the system. Nodes of outermost circle's regions will die first and after that nodes of middle circle regions will be dead and the Direct Communication nodes will die in last because they are much closer to the BS. Results shows that the stability region is 90% better than LEACH.

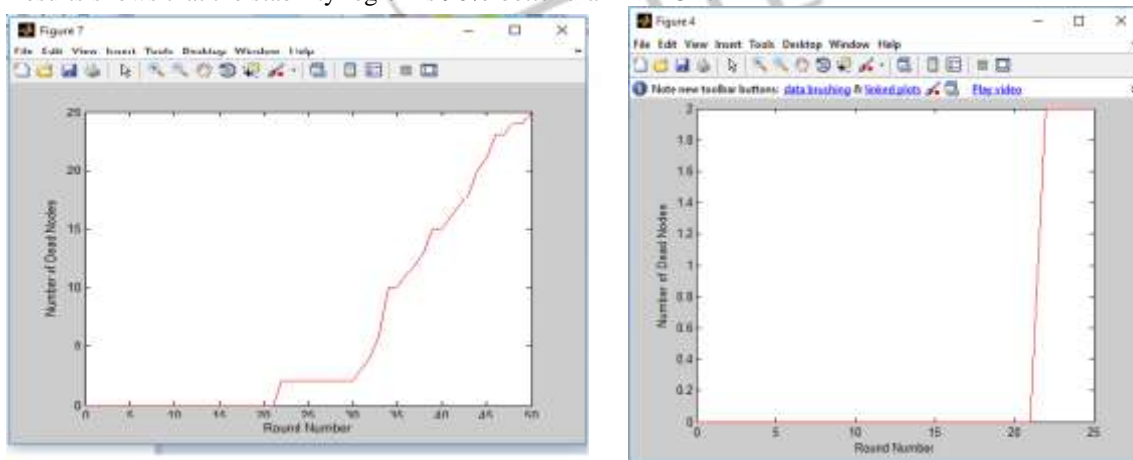


Figure 5.2 Dead nodes

5.2 PACKETS SENT TO BS

The five times averaged values of the total number of packets referred to BS per round of the network lifetime of LEACH. According to our network strategy packets referred to the BS per round should ideally follow the explanation below: Packets referred to BS by 1st Region DT nodes = 10, Packets Referred to BS by 2nd Region CH Node = 1, Packets Referred to BS by 3rd

Region CH Node = 1, Packets Referred to BS by 4th Region CH Node = 1, Packets Referred to BS by 5th Region CH Node = 1, Total Packets Referred to BS per round = 14. So, as long as all the nodes are alive the packets referred should be 14. When nodes of outer two rings start to die the number of packets gradually decrease till 2154th round and at that time only direct communication nodes are left. Now graph is constant until 2370th round and after that Region 1 nodes start to die the number of packets start to decrease. Whereas LEACH is using clustering in its network area of 100x100 and every node has the same probability to convert a CH. LEACH does not assure how many CHs will be formed during any round and in every round the number of CHs are fluctuating around 9 ($p=0.1$) when all nodes are alive, and packets start to decrease as soon as first node dies at 855th round. So the LEACH protocol forms approximately 9 CHs in its every round, so, the packets referred to BS should also be 9. So, as shown by the fig. 4 the Packets referred by LEACH in every round should be around 9 until first node dies.

VI. CONCLUSION

An energy efficient protocol has been proposed. It has been observed that higher energy efficiency can be achieved by including additional levels of hierarchy in the protocol rather than using LEACH protocol in its basic form alone. The advanced and improved LEACH protocols proved to be better than LEACH, i.e., TL-LEACH, M-LEACH, DD-LEACH. This is due to their clustering nature, two-level hierarchy of nodes, undergoing multiple hops among CHs transmitting the interested data, and following an optimal path. These factors make the improved LEACH protocols to better the energy usage and to prolong the network lifetime. In the proposed DD-TL-LEACH protocol, simulation shows better results than other two level LEACH protocol. Various simulation models for the extensions of LEACH using three different Hierarchical routing protocols have been created. A performance analysis for the same has also been carried out. From the simulation results, it can be concluded that the multi-level Hierarchical routing protocol is more energy efficient when compared to the LEACH. The lifetime of the network also gets extended.

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