Distributed Clustering Algorithm for Energy Efficient Routing In Wireless Sensor Networks

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Abstract— Wireless Sensor network has emerged as a promising technique that revolutionizes the way of sensing information. Dense deployed sensor nodes at a specific region are likely to transfer redundant data to the base station. This increase the communicational overhead and affects network lifetime. The objective of this paper is to achieve prolonged network lifetime with overall energy efficiency in Wireless Sensor Networks (WSNs) through controlled utilization of limited energy. In wireless sensor networks most of the energy spent is consumed in routing the sensed data from cluster head to base station. Back up heads are introduced to avoid frequent re-clustering in each cluster. A modification to existing clustering technique in the LEACH is done by implementing Distributed Clustering Algorithm (DCA) in LEACH protocol. The use of hierarchical or cluster-based routing helps in conserving more energy and setting of the other group members in the same cluster to a sleep mode reduces energy consumption of the WSN. This results in overall energy efficiency with prolonged network lifetime. Based on the study, the future research areas and issues to be focused are Security, Energy conservation, query processing, communication & uncertainty in sensor reading.

Keywords— Wireless Sensor Network, Distributed Clustering Algorithm, Network topologies

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions. The principal tasks of a node are computation, storage, communication and sensing. Each node in a sensor network is typically equipped with a radio transceiver, a small microcontroller, and an energy source usually a battery. These nodes are designed to meet the necessary requirements of every application in which the WSN network is being implemented. The need for energy awareness is stressed during development of the protocol as these nodes are battery-driven.

A. *Routing Techniques In WSN*

The sensor network must be connected to provide better communication. Due to the constrained radio transmission range and the polynomial growth in the energy-cost of radio transmission with respect to the transmission distance, it is very unlikely that every node will reach the base station, so the data transmission in a WSN is usually multi-hop techniques (from node to node, towards the base station). In general, routing in WSNs can be divided into flat-based routing, hierarchical-based routing, and location based routing depending on the network structure. The different kinds of the routing techniques are discussed below.

1) *Flat Routing*

The first category of routing protocols is the multi-hop flat routing protocols. In flat networks, each node typically plays the same role and sensor nodes collaborate together to perform the sensing task. Due to the large number of such nodes, it is not feasible to assign a global identifier to each node. This has led to data centric routing, where the base station sends queries to certain regions and waits for data from the sensors located in the selected regions. Since data is being requested through queries, attribute-based naming is necessary to specify the properties of data.

2) Hierarchical routing

Hierarchical or cluster-based routing, originally proposed in wire-line networks, are well-known techniques with special advantages related to scalability and efficient communications. As such, the concept of hierarchical routing is also utilized to perform energy-efficient routing in WSNs. In a hierarchical architecture, creation of clusters and assigning of special tasks to cluster-heads can greatly contribute to overall system scalability, lifetime and energy efficiency. Hierarchical routing is an efficient way to lower energy consumption within a cluster by decreasing the number of transmitted messages to the base station (BS) due to data aggregation and fusion process. Hierarchical routing mainly consists of two phases where first phase is used for selecting cluster-heads and the second is used for routing purposes.

3) Location based routing

In this kind of routing, sensor nodes are addressed by means of their locations. The distance between neighboring nodes can be estimated on the basis of incoming signal strengths. Relative coordinates of neighboring nodes can be obtained by exchanging such information between neighbors. The location of the nodes may be achieved directly by communicating with a satellite, using GPS (Global Positioning System), if nodes are equipped with a small low power GPS receiver.

4) Design Issues In WSN Routing

The design of routing protocols in WSNs is influenced by several challenging factors. These factors must be overcome to achieve efficient communication in WSNs. In the following, some of the routing challenges and design issues that affect routing process in WSNs are summarized.

Node deployment: Node deployment in WSNs is application dependent and affects the performance of the routing protocol. The deployment can be either deterministic or randomized. In deterministic deployment, the sensors are manually placed and data is routed through pre-determined paths. However, in random node deployment, the sensor nodes are scattered randomly creating an infrastructure in an adhoc manner.

Energy consumption: Sensor nodes can use up their limited supply of energy required for performing computations and transmitting information in a wireless environment. As such, energy-conserving forms of communication and computation are very essential. The lifetime of the sensor nodes shows a strong dependence on the battery lifetime. In a multi-hop WSN, each node plays a dual role as data sender and data router.

Data reporting model: Data sensing and reporting in WSNs is dependent on the application and the time criticality of the data reporting. Data reporting can be categorized as time-driven (continuous), event-driven, query-driven, and hybrid.

Node Heterogeneity: In many studies, all sensor nodes were assumed to be homogeneous, i.e., having equal capacity in terms of computation, communication, and power. However, depending on the application a sensor node can have different role or capability.

Scalability: The number of sensor nodes deployed in the sensing area may be in the order of hundreds or thousands, or more. Any routing scheme must be able to work with this huge number of sensor nodes. In addition, sensor network routing protocols should be scalable enough to respond to events in the environment.

Coverage: In WSNs, each sensor node obtains a certain view of the environment. A given sensor's view of the environment is limited both in range and in accuracy; it can only cover a limited physical area of the environment. Hence, area coverage is also judged to be an important design parameter in WSNs. Of the routing techniques presented earlier, hierarchical routing is found to be an effective technique for energy optimizations in WSNs. Clustering is found to be an effective topology control approach in WSNs which can increase network scalability and lifetime. Clustering scheme can effectively prolong the life time of wireless sensor networks by effective and efficient utilization of the limited energy resources of the deployed sensor nodes.

B. *Existing Cluster Based Protocol*

In recent years, various protocols based on clustering scheme have been proposed. These protocols vary depending on the clustering approach, the computational complexity, network density and the routing schemes. A study of these protocols is required in understanding the behavior and performance of the network and the challenges existing in sensor networks.

1) *Low-Energy Adaptive Clustering Hierarchy protocol*

Low-Energy Adaptive Clustering Hierarchy protocol LEACH (Low-Energy Adaptive Clustering Hierarchy) is one of the popular cluster-based structures. **[1]** LEACH (Low Energy Adaptive Clustering Hierarchy) is designed for sensor networks, where an end-user wants to remotely monitor the environment. In such a situation, the data from the individual nodes must be sent to a central base station, often located far from the sensor network, through which the end-user can access the data. There are several desirable properties for protocols on these networks:

- Use 100's-1000's of nodes
- Maximize system lifetime
- Maximize network coverage
- Use uniform, battery-operated nodes

Conventional network protocols, such as direct transmission, minimum transmission energy, multi-hop routing, and clustering all have drawbacks that don't allow them to achieve all the desirable properties.[7] LEACH includes distributed cluster formation, local processing to reduce global communication, and randomized rotation of the cluster-heads. Together, these features allow LEACH to achieve the desired properties. Initial simulations show that LEACH is an energy-efficient protocol that extends system lifetime. In this protocol, the nodes organize themselves into local clusters, with one node acting as the local cluster-head.

LEACH includes randomized rotation of the cluster head position such that it rotates among the various sensors in order not to drain the battery of the single sensors. The method to elect clusters is done using random probability. Each sensor chooses a number between 0 and 1, if the number is less than the threshold value; the node broadcasts itself as the cluster head. The threshold value is calculated based on a below defined equation. The equation incorporates the desired percentage to become the cluster head.

$$T(n) = \frac{P}{1 - P \times \left(r \bmod \frac{1}{P} \right)} \qquad \forall n \in G$$
$$T(n) = 0 \qquad \forall n \notin G$$

Eq 1.1 Calculating Threshold Value for LEACH

Where *P is* the cluster-head probability, *r is* the number of the current round and *G* is the set of nodes that have not been cluster-heads in the last 1/P rounds. This ensures that every node becomes a cluster-head exactly once within 1/P rounds. Looking at a single round of LEACH, it is obvious that a stochastic cluster-head selection will not automatically lead to minimum energy consumption during data transfer for a given set of nodes. All cluster-heads can be located near the edges of the network or adjacent nodes can become cluster-heads.

1).1 Drawbacks of LEACH

LEACH assumes that all nodes can transmit with enough power to reach the base station when required .Assumes that node always has data to send. The elected cluster heads will be concentrated in one part of the network leading to some nodes not having any cluster heads in their vicinity.

2) *Power-Efficient Gathering In Sensor Information System*

This protocol is a near optimal chain based protocol. [2] The basic idea of the protocol is that, in order to extend network lifetime, nodes need only communicate with their closest neighbors and take turns in communicating with the base station, a new round will start and soon. This reduces the power required to transmit data per round because the power draining is spread uniformly over all nodes. The chain in PEGASIS will consist of nodes closest to each other that form a path to the base station. The aggregated form of the data will be sent to the base station by any node in the chain and the nodes in the chain will take turns sending to the base station. PEGASIS uses assumptions that may not always be realistic. First, PEGASIS assumes that each sensor node is able to communicate with the base station directly. In practical cases, sensor nodes use multi-hop communication to reach the base station. Second, it assumes that all nodes maintain a complete database about the location of all other nodes in the network, but the method by which the node locations are obtained is not outlined. Third, it assumes that all sensor nodes have the same level of energy and are likely to die at the same time.

3) *Hybrid Energy Efficient Distributed Clustering Protocol (HEED)*

HEED is a new energy-efficient approach for clustering nodes in sensor networks. Periodically selects cluster heads according to their residual energy and a secondary parameter, such as node proximity to its neighbors or node degree. The clustering process terminates rapidly.[5] The protocol incurs low overhead in terms of processing cycles and messages exchanged, achieves fairly uniform cluster head distribution across the network and considers cluster quality, e.g., load-balanced clusters or dense clusters.Primary goal of HEED is, prolonging network lifetime by distributing energy consumption, terminating the clustering process within a constant number of iterations / steps, minimizing control overhead (to be linear in the number of nodes), producing well-distributed cluster heads and compact clusters**.**

C. *Characteristics of Clustering*

Sensor Nodes are responsible for collecting the information data caused by changes in the environment, processing and transferring the data to the cluster head. Cluster -heads are responsible for coordination among the nodes within their clusters (intra-cluster coordination) communication with each other and/or with external observers on behalf of their clusters (Inter-cluster communication).Involves grouping nodes into clusters and electing a Cluster Head (CH) Members of a cluster can communicate with their CH directly CH can forward the aggregated data to the central base station through other CHs.

1) *Objectives of Clustering*

- Allows aggregation
- Limits data transmission
- Facilitates the reusability of the resources
- Forms a virtual backbone for inter - cluster routing
- Gives the impression of a smaller and more stable network
- Improves network lifetime
- Reduces network traffic and the contention for the channel
- Allows data aggregation and data updating in cluster heads

The main goals of the project is to achieve prolonged network lifetime with overall energy efficiency in WSNs through controlled utilization of limited energy of the nodes and to optimize the clustering and routing technique by introducing backup heads and secondary membership heads. The controlled utilization of the nodes allows overcoming the problems faced in the stochastic threshold algorithm due to random selection of the nodes in the LEACH protocol. The present protocol is achieved by redesigning the selection procedure of the LEACH protocol. The project aims in improving the communication with efficient utilization of the energy while ensuring for the remote monitoring of the environment.

The remainder of this paper is organized as follows. In discusses the requirement analysis and specifications. Session 3 describes the problem definition and the methodology used. Session 4 deals with the design phase. Session 5 discusses the implementation details. Session 6 of the project gives conclusion and future work of this paper.

II. PROBLEM DEFINITION

The major issue that needs to be considered in the Wireless Sensor Networks is the network life time. In the previously available protocols, most of the energy spent is consumed in routing the sensed data from Cluster Head to the Base Station, whereas this problem is overcome in this project. Network life time is increased by routing the sensed data through cluster head by adopting Distributed Clustering Algorithm (DCA).

The DCA selects a cluster head with maximum energy level which is defined above the threshold value in addition to the cluster head a back up head is selected. The backup head is selected with the highest residual energy within the cluster, where the energy level is next to the cluster head with maximum energy level in the cluster. Routing can be carried out through the back up head in case of expiry of the life time of the cluster head.

A. *Clustering and Cluster Head Selection Using LEACH*

The operation of LEACH is broken up into rounds, where each round begins with a setup phase, when the clusters are organized. The setup phase is followed by a steady state phase, during occurrence of the data transfer operation. In order to minimize overhead, the steady state phase is long compared to the set-up phase.

1) *Advertisement Phase.*

Initially, when clusters are being created, each node decides whether or not to become a cluster-head for the current round. [6] This decision is based on the suggested percentage of cluster heads for the network (determined a priori) and the number of times the node has been a cluster-head so far.[] This decision is made by the node n choosing a random number between 0 and 1. If the number is less than a threshold T(n), the node becomes a cluster-head for the current round. The threshold is set as:

$$T(n)=\frac{P}{1-P\times\left(r \bmod \frac{1}{P}\right)} \qquad \forall n\in G$$

$$T(n)=0 \qquad \forall n\notin G$$

Where P = the desired percentage of cluster heads (e.g., P = 0.05), *r* = the current round, and G is the set of nodes that have not been cluster-heads in the last *1/P* rounds. Using this threshold, each node will be a cluster-head at some point within *1/P* rounds. During round 0 (*r* = 0), each node has a probability *P* of becoming a cluster-head. The nodes that are cluster-heads in round 0 cannot be cluster-heads for the next *1/P* rounds. Thus the probability that the remaining nodes are cluster-heads must be increased, since there are fewer nodes that are eligible to become cluster-heads. After *1/P* -1 rounds, T=1 for any nodes that have not yet been cluster-heads, and after *1/P* rounds, all nodes are once again eligible to become cluster-heads. Non-uniform energy nodes are taken into the account. In this case, we are assuming that all nodes begin with the same amount of energy and being a cluster-head removes approximately the same amount of energy for each node. Each node that has elected itself a cluster-head for the current round broadcasts an advertisement message to the rest of the nodes. For this “cluster-head-advertisement” phase, the cluster-heads use a CSMA MAC protocol, and all cluster-heads transmit their advertisement using the same transmit energy. The non-cluster-head nodes must keep their receivers on during this phase of set-up to hear the advertisements of all the cluster-head nodes. After this phase is complete, each non-cluster-head node decides the cluster to which it will belong for this round. This decision is based on the received signal strength of the advertisement. Assuming symmetric propagation channels, the cluster-head advertisement heard with the largest signal strength is the cluster-head to whom the minimum amount of transmitted energy is needed for communication. In the case of ties, a random cluster-head is chosen.

2) Cluster Setup Phase

After each node has decided to which cluster it belongs, it must inform the cluster-head node that it will be a member of the cluster. Each node transmits this information back to the cluster-head again using a CSMA MAC protocol. During this phase, all cluster-head nodes must keep their receivers on.

3) Schedule Creation

The cluster-head node receives all the messages for nodes that would like to be included in the cluster.[6] Based on the number of nodes in the cluster, the cluster head node creates a TDMA schedule telling each node when it can transmit. This schedule is broadcast back to the nodes in the cluster.

4) Data Transmission

Once the clusters are created and the TDMA schedule is fixed, data transmission can begin. Assuming nodes always have data to send, they send it during their allocated transmission time to the cluster head. This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster-head advertisement). The radio of each non-cluster head node can be turned off until the allocated transmission time of that node, thus minimizing energy dissipation in these nodes. The cluster-head node must keep its receiver on to receive all the data from the nodes in the cluster. When all the data has been received, the cluster head node performs signal processing functions to compress the data into a single signal. For example, if the data are audio or seismic signals, the cluster-head node can beam form the individual signals to generate a composite signal. This composite signal is sent to the base station. Since the base station is far away, this is a high energy transmission. This is the steady-state operation of LEACH networks. After a certain time, which is determined a priori, the next round begins with each node determining if it should be a cluster-head for this round and advertising this information. In our work, we assume a simple model where the radio dissipates Eelec = 50 nJ/bit to run the transmitter or receiver circuitry and _amp = 100 pJ/bit/m2 for the transmit amplifier to achieve an acceptable *Eb/No.* We also assume an r2 energy loss due to channel transmission. Thus, to transmit a k-bit message a distance d using our radio model, the radio expends:

ETx(k,d) = ETx-elec(k) + ETx-amp(k,d)
ETx(k,d) = Eelec* k + € * k * d*d

Eq 3.1: Transmitting K – bit message

Receiving this message, radio expends:
ERx(k) = ERx-elec(k)

$ERx(k) = Eelec * k$

Eq 3.2: Receiving K – bit message

B. Distributed Clustering Algorithm

The objective of clustering the sensor nodes is mainly to group the sensors into different groups so as to reduce the overall energy spent during communication of the sensed data to the base station. There are various clustering algorithms proposed in literature [1][2][3]&[5], but LEACH[6] "Low Energy Adaptive Clustering Hierarchy" for Ad-Hoc Sensor Networks' is found to be the energy efficient algorithm that is used for clustering. However the DCA is proposed to be more energy efficient than LEACH. In advancement to the LEACH approach, there has evolved a possibility to drastically increase the network life time.[7] DCA is proposed to vary the selection criteria of the LEACH.

1) Selection Criteria

The selection criteria is that instead of selecting only one cluster head we select two cluster heads, one acting as primary cluster head and the other acting as backup head. The node which has highest residual energy and least intra cluster communication cost is selected as the primary head for that cluster. The node with next highest residual energy with next communication cost that is least to the selected primary head is set as the backup head of that cluster.

Parameters considered for selecting Primary Head

- Highest residual energy
- Least intra cluster communication cost

Parameters considered for selecting Backup Head

- Second Highest residual energy
- Second least intra cluster communication cost.

2) Function of Backup-Head

The backup head acts as a normal node until the primary head is alive. When the primary head is about to die or when it has lost 99% of its initial energy, the power of being the cluster head is hand over to the backup head of that cluster. This yields a drastic increase in the network life time[7]. Load balancing is taken care at each cluster by limiting the number of nodes allowed in a cluster. This also depends on the type of network and density of nodes in the network.

C. Clustering and Cluster-head Selection using DCA

DCA Algorithm chooses cluster head with the maximum highest residual energy. Firstly it computes the average energy per node. Only nodes above the threshold value are eligible to be cluster-head during every round. The election of the cluster-head is performed such that the cluster-head varies for every 20 seconds. Since the nodes above the threshold value are selected, the nodes are alive for longer time and efficient energy utilization of the nodes are made possible through this algorithm.

1) Advertisement Phase

In the advertisement phase, the average energy per node is calculated before computing the threshold value for the rounds. Only nodes above the threshold value are eligible to be cluster-head during the rounds. The threshold value is set as follows:

Threshold value = Average energy / Total number of nodes   Where average energy = ∑ (Node energies in the network) during an initial phase all nodes will be having equal energy, so first few presented nodes will be set as cluster-head. Once the cluster-heads are assigned, the cluster table is created (Refer cluster table in appendix 1.3) The table contains details of the cluster head, cluster head ID, and its cluster members, then cluster is formed. After the cluster formation, backup head is assigned for each cluster. The backup head has the second highest residual energy within its clusters.

2) Cluster Setup Phase

The algorithm decides the node and the corresponding cluster. After each node has decided to which cluster it belongs, information is provided to the cluster-head node that it will be a member of the cluster. Each node transmits this information back to the cluster-head again using a CSMA MAC protocol. During this phase, the receivers in all the cluster-head nodes must be in ON state.

3) Schedule Creation

The cluster-head node receives all the messages for nodes that is decided to be included in the cluster. Based on the number of nodes in the cluster, the cluster head node creates a TDMA schedule that plans the transmission time of each node. This schedule is broadcast back to the nodes in the cluster.

4) Data Transmission

The transmission of the data is started once the clusters are created and the TDMA schedule is fixed. All nodes send their data during their allocated transmission time to the cluster head. This transmission uses a minimal amount of energy (chosen based on the received strength of the cluster-head advertisement). The radio of each non-cluster head node can be turned off until the node's allocated transmission time, thus minimizing energy dissipation in these nodes. When all the data has been received, the cluster head node performs signal processing functions to compress the data into a single signal.

D. Architectural Design

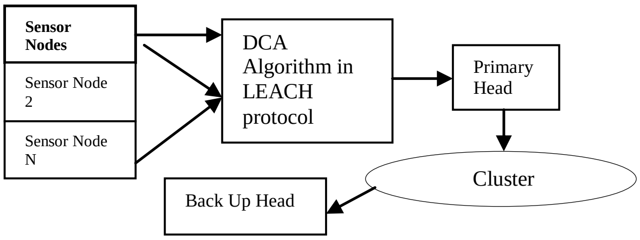

Fig 1 – Architectural design for DCA Algorithm

In the WSN network, there are 100 nodes randomly placed in the sensor field. Distributed Clustering Algorithm is applied for each node and it is implemented using LEACH to select cluster –heads and their desired cluster members. Election will be conducted by the base station and it has infinite amount of energy it will be selecting the desired cluster -heads. Once primary Head is selected clusters will be formed on the power levels of the desired cluster- head and backup - head is selected within the Clusters.

E. Distributed Algorithm Notations Used

- T - Threshold value (minimum energy required for a node to become
- a Cluster Head)
- N – node
- N.res - residual energy pf a node N
- N.my_ Cluster Head - Cluster Head to which node N belongs
- H.Nodes_Count - No of nodes in a Cluster with head H
- Max_limit - Total no of nodes / Number of cluster-head
- Is_within_range(H,N) - Check if N is within Cluster Range of H
- Range of Cluster = H.res*R(Cluster radius)
- Hset - set of Cluster Heads, NHSet - Set of Non Cluster Heads
- BHset - set of backup heads to corresponding cluster Heads
- S- Sink

1) Cluster Head Selection

For all nodes

If (N.res>=T), for all nodes,{H: H is a node in Hset}

If(is_within_range(H,N)=false)

Hset=Hset union N

Else

NHset = NHset union N;

2) Cluster Formation

For all N in NHset {NH: NH is a node in NH set}

If (NH.My Cluster_Head) = -1

For all N in Hset{H: H is a node in Hset}

If (is_within_range(H,N)= True and H.Nodes_count<max_limit)

// Check the nodes are within the range of Cluster Head

the Head node count is less than max limit

NH.My_ ClusterHead=H; for all nodes

For all nodes,

If N is a node with second highest residual energy in a cluster BHset = BHset union N.

F. Routing design

Communicating the sensed data from cluster head to the base station consumes a lot of energy. Hence energy spent in routing the data has to be controlled to achieve energy efficient routing. Nodes sense the data and send their respective data to the cluster head. The cluster head upon receiving the data from all the nodes in the cluster aggregates the data into a data packet that is to be sent to the base station. This aggregated data packet can be sent within a single hop or in multiple hops to the base station. The type of routing (multi hop, single hop) decides the energy consumed in routing the data to the base station. Single hop communication is impractical

LEACH PROTOCOL				DCA ALGORITHM			
Cluster head	Energy consumed (Joule)	Total alive nodes	Time in secs	Cluster head	Energy consumed (Joule)	Total alive nodes	Time in secs
5	42.8798	99	100	5	40.5672	99	100
5	57.0067	99	200	5	77.7411	99	200
5	78.7611	99	300	5	40.5609	99	300
5	120..5010	92	400	5	100.201	99	400
5	286..5275	47	500	5	251.651	64	500

since there is no sufficient energy in most of the heads to communicate the data directly to the base station. Most of the Multi hop communication techniques route the sensed data to the neighboring lower levels towards the base station

G. *Intra Cluster Communication*

Cluster-head determines time for a single TDMA frame. Each node sends data once per frame in the specified slot. All other group members in the same clusters are set in a sleep mode this reduces energy consumption of the WSN. After the entire frame of data has been received, the cluster-head must perform data aggregation functions and transmit the aggregated signal to the base station. The transmission time, the packet transmission time, spread spectrum transmission time and maximum

LEACH PROTOCOL				DCA ALGORITHM			
Cluster head	Energy consumed (Joule)	Total alive nodes	Time in secs	Cluster head	Energy consumed (Joule)	Total alive nodes	Time in secs
3	26.5046	99	100	3	25.5435	99	100
4	33.7196	99	100	4	33.6196	99	100
5	40.7709	99	100	5	40.5609	99	100
6	47.6955	99	100	6	44.8355	99	100
7	54.0970	99	100	7	51.6637	99	100

TDMA frame time are calculated as follows:

Transmission time = Number of bytes * 8 / Bandwidth

Packet Transmission time = Txtime (signal size + Header size)

Spread Spectrum packet transmission time = slot time * Spreading

Maximum TDMA frame time (if all anodes are in one cluster) = spread spectrum slot time * total number of nodes.

III. Simulation Results

The simulation results of the LEACH protocol and the DCA algorithm are shown in the tables below and are also represented graphically to illustrate the increment in the network lifetime and decrease in the amount of the energy consumed by the network.

A. *Simulation Result 1*

TABLE I

Comparison of Result 1 of LEACH Protocol and DCA Algorithm

The below graph is plotted using the parameters time in seconds and the number of the nodes alive after the data transmission considering the number of cluster heads as a constant parameter. The comparison graph is drawn taking the number of the cluster heads to be 5 constantly and the results obtained by considering the number of the nodes alive during the variation in the time interval. It is noted that the reduction in the number of the nodes alive in the LEACH protocol is much less than the number of the nodes alive in the DCA algorithm. The Fig. 2 is plotted using the varying parameters such cluster heads and the total energy consumed per data transmission by considering the time taken for the total transmission as a constant parameter. The graphs illustrate the decrease in the energy consumed per transmission for various cluster heads. The amount of the energy consumed by utilization of the DCA algorithm for the same amount of the cluster head is low when compared to the amount of the energy consumed in the LEACH protocol. The reduction in the energy consumed provides a greater insight on the amount of the energy preserved in this technique, thus helping in increasing the network lifetime of the WSNs.

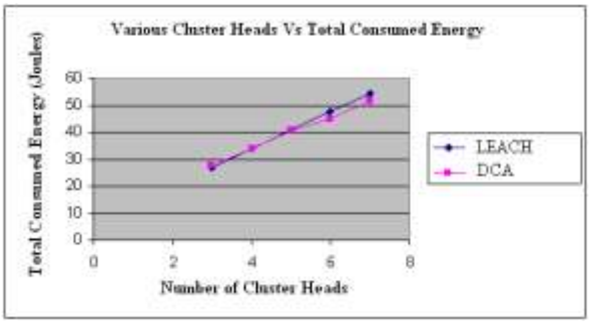

Fig.2 Comparison result 1 of Total energy consumption for various CHs

. TABLE III

Comparison of Result 2 of LEACH Protocol and DCA Algorithm

LEACH PROTOCOL				DCA ALGORITHM			
Cluster head	Energy consumed (Joule)	Total alive nodes	Time in secs	Cluster head	Energy consumed (Joule)	Total alive nodes	Time in secs
5	42.77	99	100	5	40.77	99	100
10	37.31	99	100	10	37.01	99	100
15	22.08	99	100	15	20.98	99	100
20	26.34	99	100	20	25.75	99	100

The Fig 3 is plotted using the varying parameters such as cluster heads and the total energy consumed per data transmission by considering the time taken for the transmission as a constant parameter .The graphs illustrate the decrease in the energy consumed per transmission for various cluster heads. If number of CHs increases the overall energy consumption for total transmission is automatically reduced in the WSN. When 100 nodes having 5 to 7 CHs energy consumption is more whereas increase in CHs reduces the total energy consumption is given in the table (refer table 2).

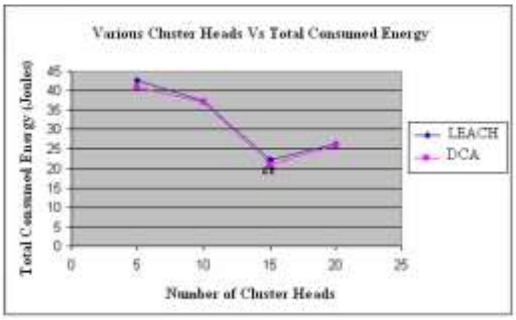

Fig 3 Comparison results 2 of Total energy consumption for various CHs

B. Simulation Result 2

The simulation experiment is conducted for 100 nodes, having 100sec as simulation time. The graph is plotted using varying parameters for total energy consumed for data transmission every 10 seconds time intervals. DCA algorithm calculates total energy for every 10 secs for the total transmission time.

C. Simulation Result 3

TABLE IIIII

Table 3: Comparison of LEACH and DCA using different topologies

LEACH PROTOCOL				DCA ALGORITHM			
Number of Nodes	Cluster heads	Energy consumed (Joule)	Time in secs	Number of Nodes	Cluster heads	Energy consumed (Joule)	Time in secs
25	5	30.31	100	25	5	27.03	100
50	8	52.55	100	50	8	51.05	100
75	15	19.47	100	75	15	19.07	100
100	20	26.57	100	100	20	25.15	100

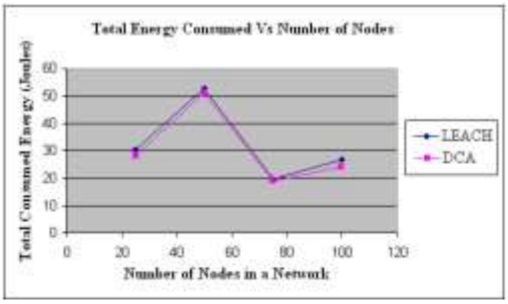

Fig 4 Comparison of Total Energy consumptions for various topologies

The simulation is conducted for different topologies using 25,50,75,100 nodes in a network and cluster-heads are varying as 5,8,15,20 accordingly. The graph 5.5 is plotted using the varying parameters such as number of nodes in a network having various cluster-heads and the total energy consumed per data transmission by considering the time taken for the transmission as a constant parameter. The results are compared with LEACH and DCA illustrates total energy consumed for total transmission using different topologies. The result shows that DCA gives better performance than the LEACH protocol.DCA proves that energy is efficiently utilized in the network.

IV. CONCLUSIONS

Overall energy efficiency of the network with prolonged network lifetime is achieved by Distributed Clustering Algorithm. In this approach, the overall energy of the networks is used efficiently by selecting the maximum residual energy node as the cluster head. This is clear from the simulation that results in the existence of more alive nodes in the Wireless Sensor Network. Further studies can be done, by allowing routing only through creation of the secondary membership heads which in turn results in the reduction of the energy wastage. The assigning of the secondary membership head eliminates the redundancy of forwarding the same data packet by more than one received cluster head. Routing is carried out only through the secondary membership heads so as to reduce the traffic in the network while the assigning of the secondary membership heads is a onetime task, thus ensuring conservation of the energy that is spent in redundant transmission.

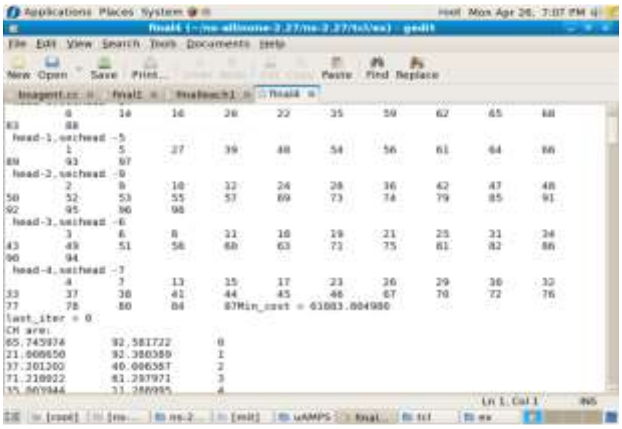

Fig A .1 Trace file for Clustertable by DCA Using 100 nodes

The below given screen shot ,A .2 shows that every 20 seconds new CH will be chosen by the DCA algorithm.

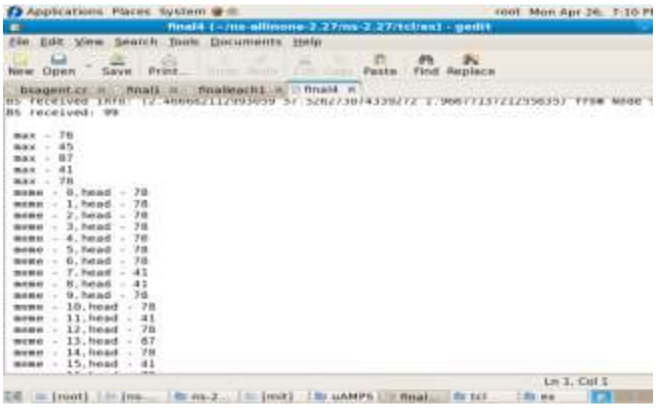

Fig A .2 Trace file for new cluster – head assignment using 100 nodes

The screenshot illustrates, new Cluster table which contains Primary Head ID, Secondary head ID and its cluster members. The node which has maximum energy will become CH. Members are inserted in the table and the node within the cluster which has second highest residual energy has become Sec- Head

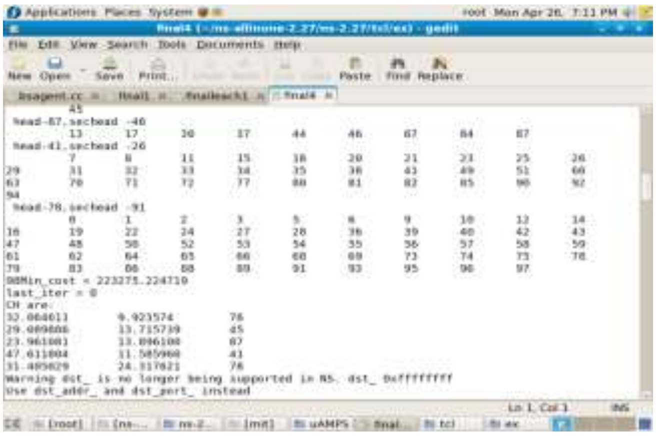

Fig A 3 Trace file for New Cluster table and its members for 100 nodes

The given screenshot shows the total energy consumed for overall transmission, Data packets sent and total no of nodes alive.

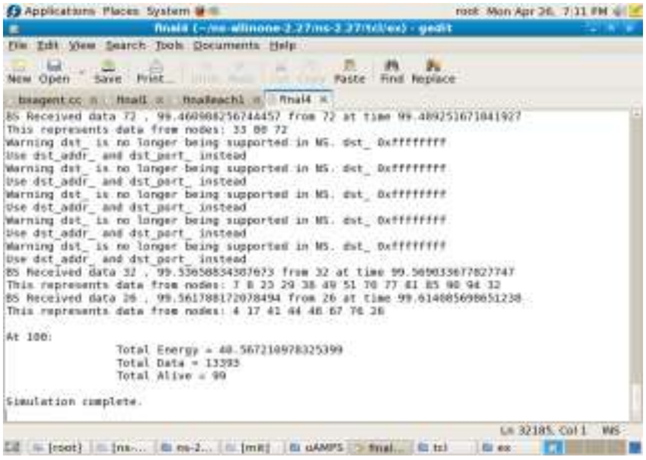

Fig A.4 Trace file for Total energy consumption using 100 Nodes

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