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A survey on variants of LEACH in WSN

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Abstract: In Sensor network Sensor node has a limited source of power. So, it is essential to have long lifetime of network by energy effective routing. To have consistent long lifetime among sensor nodes, it is prerequisite to utilize efficient clustering algorithm. LEACH is a well known routing protocol based on cluster, but it has several disadvantage about short network lifetime because of the inefficient energy consumption. Here analysis of variants of LEACH namely LEACH-E, MODLEACH, Distance-LEACH is done using MATLAB. Simulation results show that the three variant protocol performs better than LEACH in terms of the parameters under consideration. The paper will be concluded by mentioning the observations made from analyses of results about these.

Keywords: LEACH; LEACH-E; MODLEACH; Distance-LEACH, Clustering.

I. INTRODUTIONS

Wireless Sensor Networks (WSNs) consist of many sensor nodes. The configuration a sensor node includes single or multiple sensing elements, a data processor, communicating components and a battery source. Normally, the sensing elements perform measurements related to the conditions existing at its surrounding environment. These measurements are converted into electric signals and are processed by the data processor. Sensor networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar. A sensor node makes use of its communicating components in order to transmit the data, over a wireless channel, to a base station (a sink node).

Wireless sensor networks have the following characteristics:

1. 1.The node distribution is extremely dense.
2. 2.The node's capacity of processing ability, electrical power and storage is very limited.
3. 3.In the network, nodes are mostly static, and poor working conditions will make a high probability of node failure.

As the resources of sensor nodes in WSN, such as energy, computing capability and transmission bandwidth et al are very limited, it is critical to employ superior routing protocol so as to reduce node energy consumption and prolong network life cycle, which is also the major objective of WSN routing design. Currently, WSN routing protocols can be mainly divided into two categories, i.e., flat routing protocols and hierarchical routing protocols. In a relatively optimal hierarchical structure, the neighboring nodes are clustered and then a cluster head node, which is responsible for managing nodes in the cluster and communicating with the base station, can be chosen. Such a hierarchical structure can not only reduce the communication cost, but also utilize the cluster head node with higher energy to collect the data in the cluster's coverage so as to save energy and prolong the life of the network.

II. LITERATURE REVIEW

Limited energy resources of sensor nodes create challenging issues on the improvement of routing protocols for WSN. Introducing clustering into network's topology reduces number of transmissions in the network. Hence ,providing energy efficiency as CHs aggregate data from their respective member nodes as well as reducing replica of transmission and enhancing the network lifetime.

A. LEACH

Heinzelman introduced a clustering algorithm for sensor networks, called Low Energy Adaptive Clustering Hierarchy (LEACH)[1]. The algorithm randomly selects cluster heads, and the other nodes divide into groups depending on strength of the received signal from the cluster head. LEACH defines a "wheel" (Round) concept, and each wheel is made from the two stages of cluster stability and the establishment.

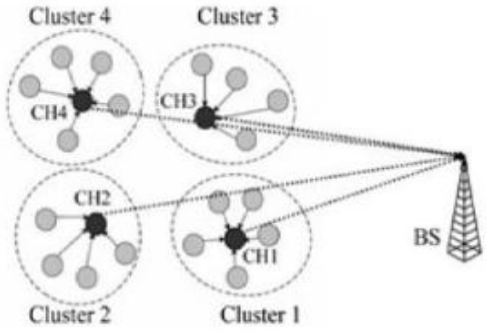

Fig. 1. Topology structure of LEACH

LEACH protocol via a distributed algorithm to form a cluster, each node independently decides whether to act as the cluster head node in the current round. For each node 'n' must be randomly generated a random between 0 and 1. If the random number is less than the threshold T (n), then the node is selected as the current round of the cluster head node.

T (n) is defined as:

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$$T(n)=\begin{cases} p/(1-p\times(r \bmod(1/p))) & n\in G \\ 0 & otherwise \end{cases} \quad (1)$$

Where p is the expected cluster head node in all the percentage of sensor nodes, r is the number of rounds that carried out, G is in the last 1 / p rounds are not served as a set of cluster head nodes[4].

After the cluster head node is selected as cluster head nodes, each cluster head broadcast the information that it become to cluster head(ADV),other non-cluster head node according to signals received by the broadcast information to determine the cluster to be added, and send a join request to the cluster head. When the cluster head node receives from the members of the "Registration" message from the members, it generate a TDMA time slot table for slot allocation of each member based on the number of members of the node, thus ensuring there is no conflict between the data sources, when each node knows own time slot then enter the stable work.

In a stable stage, the members of the nodes that belong to its own time slot send data to the cluster head, while the rest of the time the radio module can be turned off and enter the sleep state, which is one main method to save energy of LEACH. After Cluster head node receives data collected by the members of the node, it will be fusion the data and send it to the sink node.

B. Mobile LEACH

The LEACH considers all nodes are homogeneous with respect to energy, which is not realistic approach. In particular round uneven nodes are attached to multiple Cluster-head. In this case cluster-head with large number of member node will drain its energy as compare to cluster-head with smaller number of associated member nodes. Furthermore mobility support is another issue with LEACH routing protocol, to mitigate these issues, so this protocol proposed.

C. Security LEACH

It is the first modified version of LEACH with cryptographic protection against outsider attacks called Security LEACH(S-LEACH). It suggests that each node has two symmetric keys, a pairwise key shared with BS and the last key chain held by BS. S-LEACH is meant to protect only against outsider attacks. S-LEACH protects against selective forwarding, sinkhole and HELLO flooding attacks by preventing intruder to become CH. It also prevents intruder to send bogus sensor data to the CH and CH to forward bogus message.

D. MODLEACH

Here modification of LEACH is done as modified LEACH (MODLEACH) by introducing a well cluster head replacement scheme and dual transmitting power levels. Our modified LEACH, in comparison with LEACH performs well by using metrics of cluster head formation, through put and network life[3]. Afterwards, hard and soft thresholds are implemented on modified LEACH that improves the performance even more. Finally a brief performance analysis of LEACH, Modified LEACH with hard threshold and soft threshold is undertaken by considering metrics of throughput, network life and cluster head replacements.

E. K- LEACH

The K-LEACH protocol improves the clustering and cluster head selection procedure. For the first round of communication, in setup phase we use the K-medoids algorithm for cluster formation, which ensures uniform clustering. The cluster formation by K-medoids algorithm ensures best clustering and selection of cluster head using Euclidian distance at the nearer or at the center of cluster always gives most energy efficient solution in WSN. From second round onwards cluster heads are selected based on the next nearest node to the first round cluster head and so on.

F. LEACH-E

LEACH-E is the enhancement of LEACH.It involves a cluster head selection algorithm which have non-uniform starting energy level among the sensors having global slot..Each cluster has a cluster head node[5]. The protocol randomly selects cluster head node circularly, the energy of the entire network load is equally distributed to each sensor node which can achieve lower energy consumption and improve the network lifetime.

III. RELATED WORK

In this paper we consider 3 variants of LEACH i.e LEACH-E, MODLEACH, Distance-LEACH.

A. LEACH-E

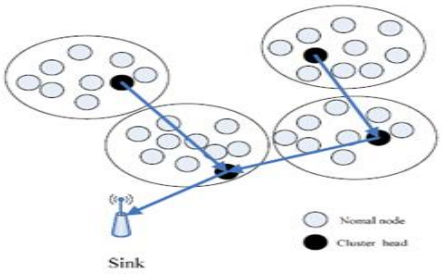

Fig.2. Architecture of E-LEACH

Also here we propose a routing protocol called LEACH-E based on LEACH protocol to balance the energy consumption of sensor nodes in order to solve the overload energy consumption problem[2]. Fig.2 depicts the architecture of E-LEACH. The random selection algorithm for LEACH easily leads to the imbalance of the stored energy of sensor nodes, thereby, the consumption of system energy is increased. To ensure that the energy load is uniformly distributed throughout the network, the additional parameters including the residual energy and the consumed energy for transmitting data are applied to optimize the process of cluster head selection[4]. The main idea of the improved cluster head selection algorithm is to avoid the lower residual energy nodes and higher

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consumed energy nodes to be cluster-head. A new $T(n)$ is defined as follow:

$$T_{new}(n) = \begin{cases} \frac{p_{head}}{1-p_{head}(r*\bmod(1/p_{head}))} * \frac{E_{current}}{E_{initial}}, & \text{if } n \in G; \\ 0, & \text{else} \end{cases} \quad (2)$$

Where the Ecurrent is the residual energy of nodes at the *r* round,Einitial is the initial energy of nodes. By using Tnew(n), the possibility for low residual energy nodes being cluster head is greatly reduced and the possibility for high residual energy nodes being cluster head is increased.

$$p_{head} = \sqrt{\frac{N}{2\pi}} \sqrt{\frac{E_{fs}}{E_{mp}}} \frac{M}{d_{toBS}^2 \times N} \quad (3)$$

In the E-LEACH, the value of phead is dynamically calculated according to the formula (3).Then, sensor node is randomly assigned a number between 0 and 1, if value of the number is less than Tnew(n), the sensor node is selected as the cluster-head at the current round.In the steady-state phase, each node sends the collected information during its own TDMA time slot. The cluster head sends the final data to the sink by the minimum spanning tree.

B. Distance LEACH

Let 'num_ClusterNodes' denote no of cluster nodes and 'Eligible_list' denote list of cluster nodes who are eligible for role of CH. 'avg' denote average of all energies received by CH. 'dsquare' denote square of distance between two nodes. The algorithm followed by each CH within each cluster for every round is the algorithm first finds average of all energies of cluster nodes and determine who are eligible as next CHs. List of eligible cluster nodes are nodes whose energy is more than average energy. Now, each eligible CH finds its cost by calculating its distance from all cluster nodes and summing up each distance. So, the eligible node whose cost is less among all in Eligible_list will be chosen as next CH.

C. MODLEACH

Basically, we try two techniques to improve network life time and throughput. To understand the proposed scheme, there is a need to understand mechanism provided by LEACH. This protocol randomly selects the cluster head at every round and once a cluster head is selected, it will not get another opportunity for next 1/p rounds[3]. For each round, cluster heads are replaced and whole cluster formation process is repeated. We, in this work, modify LEACH by introducing "Improved cluster head replacement scheme". This describes threshold in cluster head formation for very next round. If existing cluster has not spent much energy during its period and has more energy than required threshold, it will remain cluster head for the next round. So from this, energy wasted in routing packets for new cluster head and cluster formation can be saved. If cluster head has less energy than required threshold, it will be replaced according to LEACH algorithm. We also introduced two different levels of power to amplify signals according to nature of transmission. Intra Cluster Transmission, Inter Cluster Transmission, Cluster Head To Base Station Transmission are the three steps for transmission. Intra Cluster Transmission deals with all the communication within a cluster. The transmission/ reception between two cluster heads can be termed as inter cluster transmission while a cluster head transmitting its data straight to base station lies under cluster head to base station transmission. For inter cluster or cluster head to BS communication minimum energy is required and amplification energy required for intra cluster communication cannot be same.

Moreover, multi power levels also reduce the packet drop ratio, collisions and or interference for other signals. Finally, soft and hard threshold schemes are also implemented in MODLEACH that gives better results.

IV. SIMULATION RESULTS

In this section, we mainly use simulations to analyze and evaluate the performance of the algorithm. Here Matlab is used as tool to simulate all the method. To verify the improved algorithm proposed, we will compare the results with LEACH. The basic simulation parameters for our model are mentioned in Table I. The experiment is carried out by using the same energy source whose initial energy is 0.5J. The fusion coefficient is 0.5. Every node transmits a *k* bits data packet per round to its cluster head. The size of a control packet *L*ctrl is 100 bits.To simplify the simulation of these protocols few assumptions are made. Such as Initial energy of nodes is same, Nodes are static,Nodes are assumed to have sufficient transmission range to reach other nodes[5].

TABLE I. Transmission Parameters value etc..

Description	Symbol	Value
Number of nodes	*N*	100
The initial node energy	*E*initial	0.5J
Energy consumed by the amplifier to transmit at a short distance	*E*fs	10pJ/bit/m^2
Energy consumed by the amplifier to transmit at a longer distance	*E*mp	0.0013pJ/bit/m^4
Energy consumed in the electronics circuit to transmit or receive the signal	*E*elec	50pJ/bit
Data packet	*k*	4000 bits
Control packet	*L*ctrl	100 bits
Data aggregationn energy	*E*da	5pJ/bit
The cluster probability of LEACH	*p*	0.05
The Sensing area	*M*×*M*	100m×100m

A hundred sensor nodes are arranged randomly in the field of 100m×100m square meters. The sink node position is varied accordingly. The graphs are number of packets delivered to BS, number of alive nodes, number of dead nodes with respect to time and Total Energy dissipated, Network life time with respect to Base Station location

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For MODLEACH network parameters as follows :

TABLE II.Network Parameters

Network Parameters	Value
Network Size	100X100m^2
Initial Energy of Sensor Nodes	0.5 J
Packet Size	4000 bits
Transceiver idle state energy consumption	50 nJ/bit
Data Aggregation/ Fusion Energy consumption	5 nJ/bit/report
Amplification Energy (Cluster to BS)d >= do	Efs =10pJ/bit/m^2
Amplification Energy (Cluster to BS) d <= do	Emp =0.0013pJ/bit/m^2
Amplification Energy (Intra Cluster Comm.) d >= d1	Efs/10 = Efs1
Amplification Energy (Intra Cluster Comm.)d <=d1	Emp/10 = Emp1

We have considered following parameters for LEACH and its variants:

- Rounds v/s No of data signals received at BS
- Time v/s Total energy dissipation
- Rounds v/s Number of nodes alive
- Number of nodes v/s Network Lifetime
- Base station location v/s Network Lifetime
- Rounds v/s Number of nodes dead

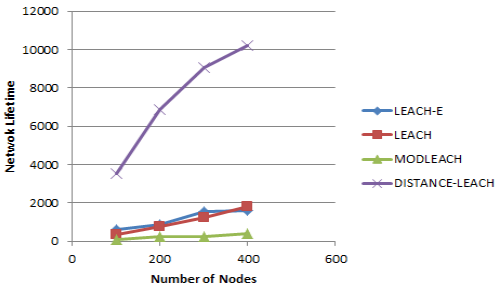

Fig. 4. Number of nodes v/s Network Lifetime

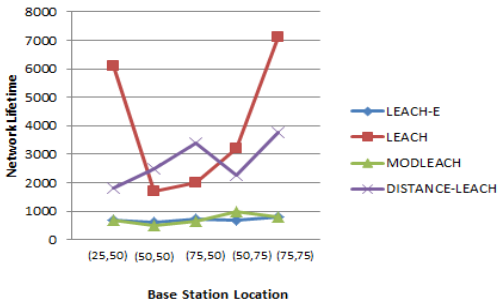

Fig.5. Base station location v/s Network Lifetime

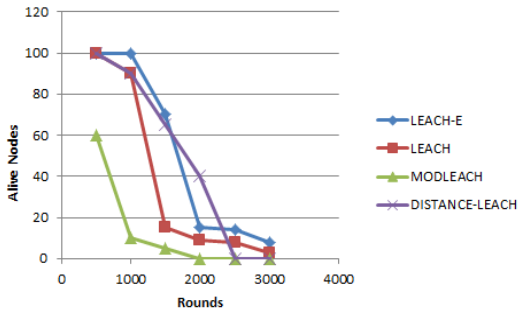

Fig.6. Rounds v/s Number of nodes alive

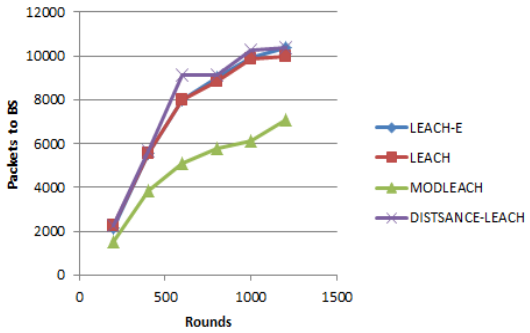

Fig.7. Rounds v/s No of data signals received at BS

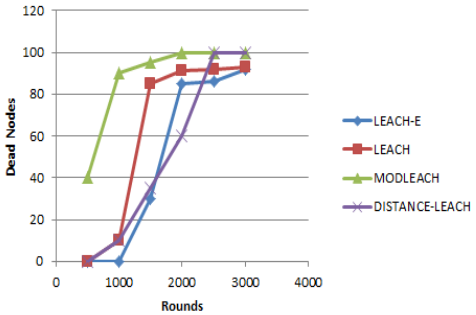

Fig. 8. Rounds v/s Number of nodes dead

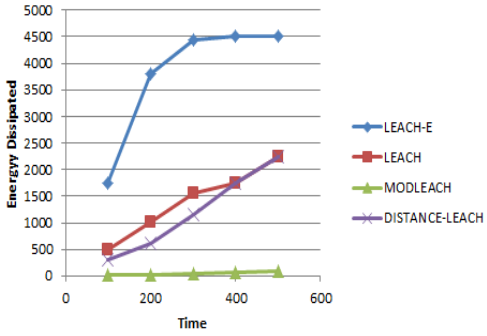

Fig.9. Time v/s Total energEy dissipation

V. ANALYSIS OF RESULTS

It is observed from the graph in Fig. 4 that Distance LEACH has better network lifetime due to the selection of cluster heads from eligible list of nodes. Fig. 5 conveys that location of BS also influence network lifetime. As BS moves far from network, distance between node and BS increases, and hence network lifetime will be less. Fig. 6 briefs that number of alive nodes is more LEACH-E and MODLEACH shows under performance. It is observed from the graph in Fig. 7 that as the number of rounds increases, packets received at BS through Distance-LEACH linearly increase compared to that of LEACH and able to deliver more data signals compared to that of LEACH and other variants because, in Distance-LEACH, calculation of average energy and cost of each cluster head is done. From Fig. 8 we can infer that in MODLEACH nodes will die soon. Graph in Fig. 9 shows that total energy dissipated is less in MODLEACH due to efficient cluster head replacement scheme and it uses low energy level for intra cluster transmissions with respect to cluster head to BS transmission leads in saving much amount of energy.

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VI. CONCLUSION

Wireless Sensor Networks, which may be spread over vast geographical area, are finding applications in many areas. In this context, there is need of approaches which can manage these WSNs in better way. In this regard, this paper, presented the need for clustering to overcome several limitations of WSNs. Brief working of chosen clustering protocols, namely LEACH-E,MODLEACH and Distance LEACH are presented. We also presented the simulation results and analyses of these protocols. As a conclusion of observation from results, the presented improved three variants of LEACH performs well in some of the network parameters according to the analysis of the results considered.

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