Energy Conservation Clustering in Wireless Sensor Networks for Increased Life Time

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***Abstract*— Energy has always been the main issue for wireless sensor networks because in many situations battery recharging or replenishment is not possible. Many solutions have been provided for energy conservation. Clustering protocols have been successful for solving this issue to an extent but are not perfect. In our proposed algorithm we utilize the ability of the sensor nodes to control their transmission power range. By utilizing this ability we are able to minimize their intra cluster energy. Although this is local energy saving but this leads us to minimization of overall network energy consumption. The other thing that can be considered is about the task of a cluster head in clustering algorithms where cluster-head is doing the task as transmitter and receiver simultaneously. Providing these tasks to a single node is not efficient. So we are introducing the notion of a special node called s-node where this s-node is working as a transmitter for a cluster and sending the aggregated data to the sink. We have simulated the proposed scheme with LEACH and LEACH-C protocol and simulation results show that the proposed scheme is better in terms of network life time than both protocols.**

Keywords*— *Clustering; Network Life Time; Optimization; S-Node; Transmission Power; Wireless Sensor Networks.

I. INTRODUCTION

The LEACH (low energy adaptive clustering hierarchy) has become the classical protocol for clustering algorithms which provide network longevity by dividing network into clusters [1] [2] but in most of the clustering protocols proposed in literature [3], each cluster head is a relay node for transmitting data to sink simultaneously and vice versa [4]. Employing nodes as cluster heads and relay node simultaneously is not optimum because sending and receiving, these two are the most energy consuming tasks in network operation and allocating these tasks to a common node at the same time will result in depletion of the node's energy level quickly [5]. This implies that simultaneous assignment of the role of sender and receiver to nodes is not a good option.

Energy consumption of nodes can also be managed by adjusting their transmission power levels. That is the main idea that is used in the proposed algorithm. Intra cluster energy, which is the average energy consumption inside a cluster, can be reduced in this way and thus this local saving will result in network level energy reduction. The parameter 'number of neighbours' (degree) can be proposed in this context for the connectedness of the network.

II. RELATED WORKS

In hierarchical clustering protocols [6] whole network is divided into several clusters. One node in each cluster is given a leading role called as cluster head. Usually cluster-head is the only node that can communicate to sink in clustering protocols [7]. This significantly reduces the transmission overhead of normal nodes because normal nodes have to transmit to cluster-head only. A brief discussion about some of the hierarchical clustering protocols is given below.

LEACH selects nodes as cluster heads (CH) based on round-robin fashion for ensuring distributed energy consumption among all the nodes. The protocol assumes that the CH will always receive correlated data and it will aggregate this data before sending to data sink. The protocol consists of two phases: set-up and steady-state.

In the set-up phase, CH is selected and clusters are formed, and in the steady state, the data transfer to sink is done. In set-up phase, a predetermined fraction of nodes generate a random number between 0 and 1. If the random number is less than a threshold T_n then the node becomes a CH, otherwise the node is expected to join the nearest cluster head in its neighborhood. The threshold value is given by expression:

$$T_n = \begin{cases} \frac{p}{1-p(r*mod(\frac{1}{p}))} & if \ n \in G \\ 0 & otherwise \end{cases} \tag{1}$$

Where r is the current round, p is the probability for each node to become CH and G is the set of nodes that have not been cluster-head in the past $1/p$ rounds. Besides all of the advantages of LEACH, it also has some disadvantages. LEACH assumes that data can be transmitted with highest transmission power by all nodes to reach the sink which results in high intra cluster energy consumption. LEACH doesn't support large network areas. In addition to it, in leach every node has equal chance of being cluster head and it does not ensure fair distribution of cluster heads.

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LEACH-Centralized (LEACH-C) is similar to LEACH protocol in the perspective of that it also has the cluster head and cluster formation concept but in LEACH-C sink is the entity that makes the decision of which nodes will become cluster-heads but problem is that it is very much affected by the location of the sink and once the energy cost of communicating with the base station becomes higher than the energy cost for cluster formation, LEACH-C does not provide good performance.

III. PROPOSED ALGORITHM

We consider a wireless sensor network consisting of N sensors uniformly distributed. Basic assumptions that are made for underlying network scenario and the sensor nodes are:

1. The base station is located far from sensor environment. Sensor nodes and base station are all stationary after installation.
2. Periodically the recently sensed data and information by all nodes are gathered and sent to the data sink after aggregation.
3. Nodes are identical with respect to energy and processing abilities. Each sensor node is having a unique identifier (ID).
4. Sensor nodes are capable of controlling their power level to adjust the amount of transmission power according to the distance to the intended recipient.
5. A node can find the distance to another node based on the received signal strength if the power of transmitting node is known.

The cluster head receives the data from its members and aggregates them before sending this huge data to the base station. All these activities deplete the nodes' energy level very fast. So another s-node is being planned to be selected to do the job of transmission to the base station. An attempt has been also made to use the nodes' ability to change their transmission power levels so that they can communicate to their intended recipient in efficient way with that transmission power only [8].

LEACH defines a parameter k_{optm} (optimal number of CHs) but a different parameter k_{ini} is taken in our scheme which is greater than k_{optm} to obtain well distributed CHs. The k_{ini} is set to have value greater than k_{optm} because we want that only high energy nodes cover the whole network area and this value is taken as double of k_{optm}. Every node will calculate a threshold value T_n described in equation 1 and will generate a random number between 0 and 1 and if this value is less than the threshold value then the node will elect itself as 'appropriate candidate node'(app-node) for becoming cluster head. All the required steps of every round are shown in the Fig.1. In the proposed algorithm in the beginning of every

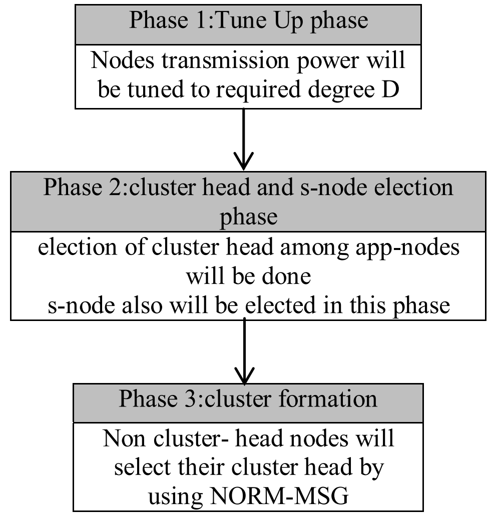

Fig. 1. Tune-up phase, Cluster head and s-node election phase, cluster formation phase

round these app-nodes will employ tune up phase which is described below:

A. Tune-up Phase

Controlling of the nodes' transmission power levels may result in the loss of network connectivity. So for becoming sure about the network connectivity throughout its life time we have used the result that is proposed by Xue and Kumar in [9]. They proved that the result given in [10] is not valid for large networks. They state that a large network of 'n' nodes will be asymptotically connected if each node connects to at least $5.1774 \log n$ closest neighbors. So we define a degree threshold (D) as $D = 5.1774 \log n$ that will preserve network connectivity.

So for the app-nodes to set their transmission power level to required degree D the proposed method is:

- app-node will send a message 'update-msg'.
- The receiving nodes will send the acknowledgement for the 'update-msg'.
- The app-node will count all these acknowledgements.
- Now if acknowledgements are equal to required degree D then set this transmission power level as base power level.
- Otherwise if acknowledgements are less than D then app-node will increase its transmission power level until the required degree D is achieved and will set this transmission power level as its base power level.
- Otherwise if acknowledgements are greater than D then app-node will decrease its transmission power level until the required degree D is achieved and will set this transmission power level as its base power level.

In this way these app-nodes will be tuned up to the required degree D as intended.

B. *Cluster-head and s-node election phase*

The proposed method for election of cluster head and s-node is:

- The app-node will broadcast the contention message 'contention-msg', which consists of their residual energy, at their set transmission power.
- Each candidate will compare its residual energy with other app nodes.
- If candidate's energy level is highest then it will elect itself as cluster head.
- Then the candidate with the second highest residual energy will elect itself as s-node (if there is no other app-node then at the time of cluster formation highest residual energy node except cluster head will become s-node).
- The remaining nodes with lower residual energy will back-off and they will act as normal nodes.

While election of cluster head the candidate with second highest residual energy will save the node id of highest residual energy node because it is going to become the cluster head for its cluster. After that the s-node will send a message 's-node-msg' to this cluster head and after receiving this message cluster head will acknowledge that message. In this way s-nodes for every cluster will be chosen. The cluster head will gather the sensed data from normal nodes of its cluster and after aggregation this cluster head will send aggregated data to its cluster's s-node. Then the s-node will send this data to the sink. In this way most energy consuming communication task is distributed throughout the network by cluster head nodes and s-nodes.

C. *Cluster Formation*

In the last step, non-cluster head nodes will be assigned to CHs for cluster formation. After electing CHs they send CLHD-MSG. Normal nodes will acknowledge a CLHD-MSG message by 'NORM-MSG' containing its ID, to the CHs. Normal nodes may receive more than one CLHD-MSG and they will acknowledge the message that will have higher signal strength. In this way cluster formation takes place. Fig. 2 shows the flow of all the steps.

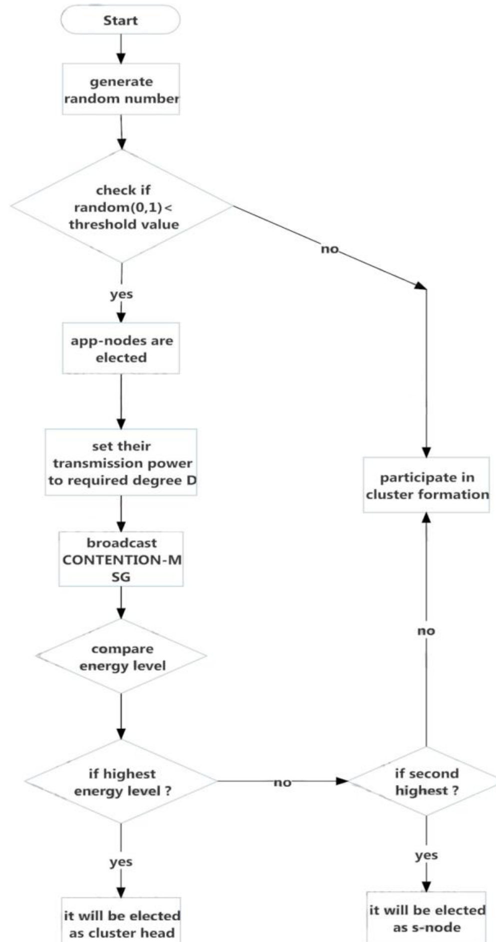

Fig. 2. Flow Chart of Proposed Scheme

IV. SIMULATION AND ANALYSIS

A. *Simulation Environment*

In this part, we evaluate the performance of the proposed scheme and compare its performance with LEACH protocol, using the same energy model used in leach protocol with same initial values and same scenario. The experiments are done with diverse number of nodes placed in a $100m * 100m$ field. Each sensor node is assumed to have an initial energy of 0.5 joules. The general simulation parameters are shown in table 1.

Table 1 Simulation Parameters

Parameters	Value
simulation area	$100 * 100$
initial energy	$0.5\,J$
Sink	$50 * 125$m and $50 * 175$m
transmission electronics	$50\ nj/bit$
nodes	100 and 300
ε_{fs}	$10\ pJ/bit/m^2$
ε_{mp}	$0.0013\ pJ/bit/m^4$
Data size	$500\ bytes$
E_{DA}	$5\ nJ/bit/signal$

B. *Simulation Analysis*

Network lifetime is defined until the first node dies. The results of network lifetime are described in Fig. 3 and Fig. 4. It is concluded that the proposed algorithm improves lifetime of nodes. With our approach first node remain alive in the network longer than LEACH and LEACH-C for both the

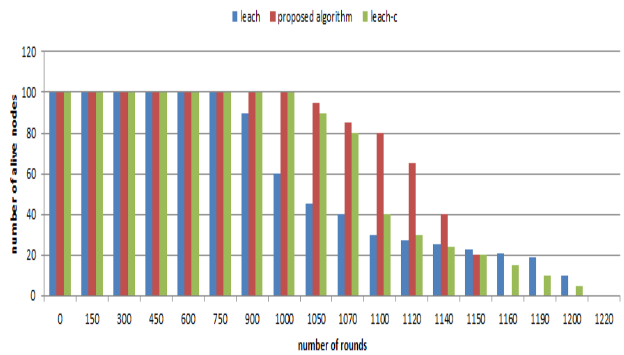

Fig. 3. Number of alive nodes (100 nodes)

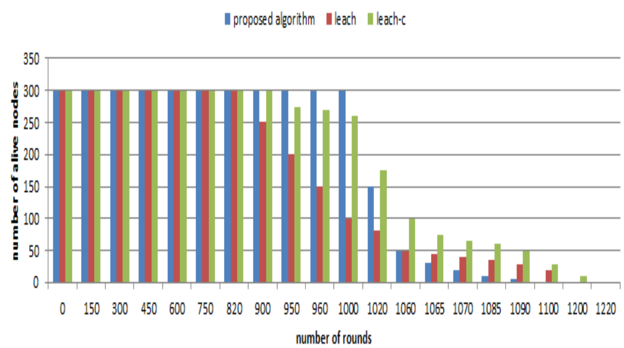

Fig. 4. Number of alive nodes (300 nodes)

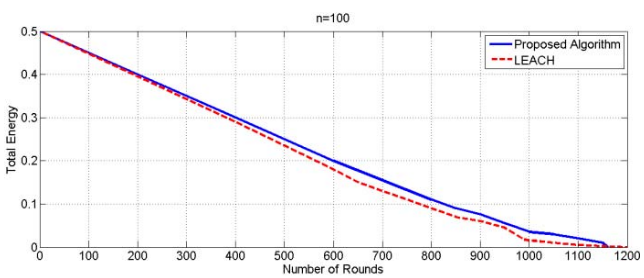

Fig. 5. Energy dissipation for 100 nodes

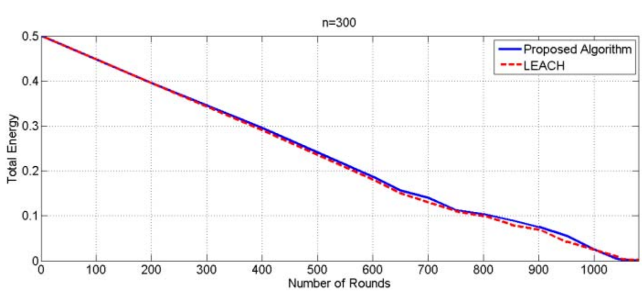

Fig. 6. Energy dissipation for 300 nodes

cases. This is because in LEACH, for becoming CH all nodes have same chances. With proposed approach first node dies around 1050 round for first case (n=100) while for leach it dies around 850 round. For second case (n=300) also with proposed algorithm first node dies around 1010 while for leach it dies around 830. Fig. 5 and Fig. 6 shows the average total energy dissipation of all nodes in network which shows that with proposed scheme nodes sustain energy for longer time than LEACH in both the cases.

V. Conclusion

A new methodology for improvement of clustering algorithm of WSN is introduced in the paper. We use the capability of the nodes of changing their transmission power levels and also introduce the notion of special nodes (s-node) for sending the aggregated data of cluster heads to the sink. Thus these improvements show that the proposed method is having longer life time for wireless sensor networks than LEACH and LEACH-C protocols. Detailed simulations of wireless sensor network environment demonstrate that our approach is a good candidate and has the ability of extending the life time of the whole network.

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