An Energy Efficient Routing Algorithm using Novel Cluster Head Selection Strategies

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ABSTRACT
The applications of wireless sensor networks (WSNs) are immense in diverse fields, which mark their importance in our daily lives. There has been a drastic change in the structure and size of WSNs in the recent years due to the technological advancements. The main challenge that the WSNs are facing still today is the extension of the sensor networks life time. There are many reasons for the wastage of energy in sensor nodes in which, the communication has a significant role to play. Hence the importance of energy efficient routing protocols. Energy efficiency in Wireless Sensor Networks is a hot research area. Many routing protocols are proposed to improve the energy efficiency of Wireless Sensor Networks. LEACH is a classical routing protocol in this area .This paper gives an overview of LEACH and the existing energy efficient routing protocols, which are the different variants of LEACH. Along with that a proposal for a new energy efficient routing algorithm named MMS-LEACH is also given.

Keywords
Clustering, Energy Efficiency, LEACH, Routing Protocols, Wireless Sensor Networks.

1. INTRODUCTION
WSNs are used in a wide variety of applications like habitat monitoring, smart home applications, precision agriculture, surveillance applications and so on. The major problem faced in all these applications is the efficient use of the limited energy available so as to extend the lifetime of the network. The wireless sensor nodes consist of a transceiver unit, a sensing and processing unit and the power source for the sensing, processing and communication functions. The power sources are usually batteries with limited power capacity due to its small size and are usually irreplaceable. Moreover the applications of these wireless sensor networks are in situations where the human intervention is difficult or impossible. If any of the nodes dies off the entire network can fail and the desired use of the network may not happen. So it is important to use the limited available energy efficiently so as to prolong the network lifetime. Research in this field has shown that the majority of the energy is consumed for communication rather than that of sensing and processing. So the developments of newer energy efficient routing protocols are essential in this area. The routing algorithms are classified into different categories like flat, hierarchical, location based etc. Majority of the energy efficient routing protocols falls under the hierarchical category which uses the clustering concept which has the ability to reduce energy consumption thereby enhancing the network life time [1].

2. MOTIVATION AND CONTRIBUTION
There are many existing energy efficient routing protocols for WSNs but each have its own advantages and drawbacks. LEACH is a traditional protocol in WSNs. Many variants of LEACH are also available. LEACH has the advantage of energy efficiency and simplicity but does not support mobility of the nodes and the election of the cluster head is random, not based on the residual energy which is not uniform.

The literature shows majority of the works related to energy efficient routing protocols in WSNs do not consider the mobility factor of the sources or sinks [1]. So we are proposing a model which takes this factor into consideration and at the same time achieving energy efficiency.

3. ORGANIZATION
The remainder of this paper is organized as follows: Section IV reviews the related work; Section V describes the LEACH algorithm; new proposed model is given in Section VI; Section VII makes a comparison of the two algorithms and Conclusions are presented in Section VIII.

4. RELATED WORK
Ahlawat and Malik in [2] proposes an advancement of LEACH called VLEACH in which the concept of vice cluster head is introduced. According to them the vice cluster head acts as the cluster head only when the original cluster head dies off. Here the selection of the vice cluster head is based on some factors like maximum residual energy, minimum distance etc and the author claims the situation of cluster head failure never happens and hence the lifetime is improved.

In [3] two protocols; energy-LEACH and multihop-LEACH are proposed. In energy-LEACH the selection of cluster head is based on nodes with more residual energy wherein cluster head and sink communicates through multihop rather than single hop in multihop-LEACH. Both protocols outperform the traditional LEACH.The authors in [4] has done a thorough study of the defects of LEACH protocol. Along with that the problems of uneven clustering based on RSSI ranging algorithm is done. In order to enhance the network life time the concepts of uneven clustering, cluster head selection based on energy levels and the ranging algorithm based on the statistics of the nodes are adopted. In [5] an improvement of LEACH called LEACH-R is proposed where a reduction in the low energy nodes being selected as cluster heads is done. Distance to the base station and the residual energy of nodes are considered for selecting the relay node from the different cluster heads. Simulation reveals that LEACH-R could balance the network energy consumption and increase the network lifetime effectively.

Mu Tong and Minghao Tang in [6] proposes LEACH-Balanced protocol which introduces an additional round after the preliminary cluster head selection using LEACH. In the second round nodes residual energy is taken in to consideration. The authors claim that because of this the number of cluster heads is constant and optimal per round.

In [7] the mobility of nodes is considered. The authors propose an enhancement of LEACH-M called LEACH-ME in this paper. The reconnection mechanism of the isolated node in LEACH-M and LEACH-ME are the same. The authors says that at low mobility the communication rate of LEACH-M and LEACH-ME are almost same but as the mobility factor is increased LEACH-ME shows much better performance.

In [8] LEACH-SCH is proposed in which a new mechanism to select the cluster head based on a new threshold value computation is used. The supporting cluster head concept is adopted. The simulation reveals it is better than the LEACH. An improved LEACH for application specific wireless sensor networks is proposed in [9]. Here redundant nodes are filtered out the beginning of each round and big clusters are splitted into smaller ones to have energy balance. Simulation results show that energy consumption is reduced considerably in the proposed protocol compared to LEACH.The I-LEACH, a new method of cluster head selection is proposed in [10]. This protocol concentrates only on small networks like home network where the cluster heads will be very less and usually one or two. In [11] LEACH-NEW is proposed where a new computation strategy for the threshold value selection is adopted. Besides, the residual energy, distance factors are also considered to formulate this protocol.In LS-LEACH, Light weight Secure LEACH data integrity, authenticity and availability is given importance along which energy consumption is also made balanced [12].

5.OVERVIEW OF LEACH ALGORITHM

LEACH is a hierarchical protocol. LEACH stands for Low Energy Adaptive Clustering hierarchy. This algorithm was first proposed by W.B.Heinzelman. According to LEACH the nodes will not be sending data directly to the sink; instead cluster heads will be responsible for aggregating the data and forwarding to the sink

The LEACH operation is performed in rounds with two phases; the Setup Phase and the Steady State Phase. In the Setup Phase the formation of clusters and the selection of the cluster heads happen. Cluster heads will be selected in each round based on some stochastic algorithm in such a way that the same node can't become the cluster head again and again. So to an extend energy balance is maintained in the network. In the Steady State Phase the cluster heads will transmit data to the base station. This phase consumes more time than the previous phase in order to avoid overheads [3] [6].

5.1. Leach Procedure

The LEACH algorithm can be informally described as follows.
Step 1: Set Up Phase-Formation of clusters and cluster head
a) For a node to become the cluster head, a random number between 0 and 1 is generated, and if that value is less than the threshold value T(n), that node will be the cluster head for that particular round. The threshold value T (n) is defined as; $T(n) = p/(1-p \times (r \bmod p^{-1}))$ if $n \in G$ and 0 otherwise; where n is the node, p is the desired cluster head percentage, r is the current round number, G is the set of all nodes that haven't become the cluster head for the last 1/p rounds.

b) Each cluster head sends advertisement messages to all other nodes.

c) The nodes which are not cluster heads responds to the advertisement based on the received signal strength and sends a join packet message with their id's to their respective cluster heads.

d) Cluster heads after receiving the id' s of all its member nodes assign TDMA scheduling by randomly picking up the CSMA.

Step 2: Steady Phase -Transmission of data to the base station or sink.

a) Each node transmits the data to its cluster head in the assigned time slot. [7][8][9].

5.2 Advantages And Limitations Of Leach

The advantages of LEACH are, it is energy efficient and outperforms the conventional communication protocols in terms of energy dissipation, ease of configuration and the network lifetime. It does not need any control information from the base station and is fully distributed. But the drawbacks include; non uniformity in the selection of cluster heads which can lead to energy deterioration of nodes as it does not take into consideration the residual energy levels. It is designed for small coverage areas and does not really support dynamic clustering [3] [4] [13].

6. MODIFIED LEACH ALGORITHM

Taking into considerations the drawbacks of LEACH especially related to the selection of the cluster head a new strategy is proposed wherein the cluster head will be selected based on residual energy, received signal strength and the minimum distance between the node and the sink where the sink is mobile. In a cluster the node closest to the sink with comparatively better residual energy will perform the duties of cluster head.

6.1 Assumptions

Certain assumptions are made for the establishment of this proposed algorithm. Here initially all nodes are having the same amount of energy and are deployed randomly in a uniform area. There can be multiple mobile sinks and the sinks are rechargeable. After the cluster is formed duty cycling is done so that all nodes within the cluster need not be alive all the time. For a set of clusters there will be a representative cluster which be alive for a particular duration and they take turns in each round. The path of the mobile sinks will be in such a way as to assist the cluster head to send data within a smaller distance. The proposed algorithm is MMS-LEACH i.e. Multiple Mobile Sink LEACH.

6.2. Aim

The aim of this proposed algorithm MMS-LEACH is to enhance the energy efficiency thereby extending the lifetime of the entire network. The proposed algorithm will be better in terms of delay factor also. It is compared with the LEACH algorithm to attest its energy efficiency.

6.3. Advantages

Since the sinks are mobile the number of hops for packet delivery can be reduced and hence the delay can be avoided. The duty cycling introduced within the clusters saves energy to a great extend.

7. SIMULATION AND COMPARISON

Here the comparative analysis of the MMS-LEACH with LEACH is done. MATLAB is used for simulation. The simulation is done in by randomly deploying 100 nodes in 100X100 areas. All nodes are of homogeneous types. There are multiple mobile sinks in which one is static. Rest of the sinks can move to the cluster heads based on the particular routing technique adopted in this algorithm. All parameters are set as the

same for the usual simulation of LEACH. The node deployment done randomly is given in Figure.1.

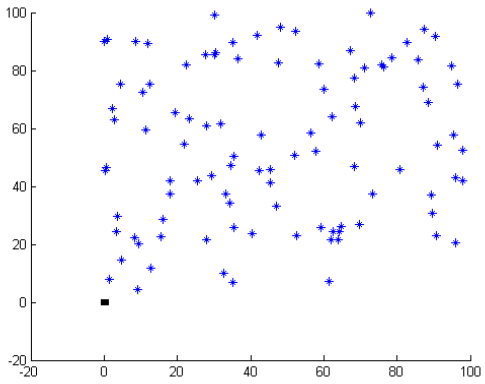

Fig.1: Node Deployment

When we compare the Figure 2 and Figure 3 it is clear that the first node death happens much later in MMS-LEACH compared to the LEACH and all nodes dies off in LEACH faster than that of the MMS-LEACH.

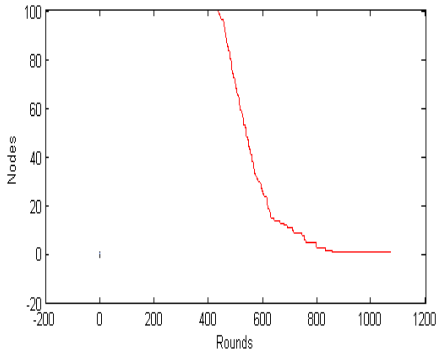

Fig 2: MMS-LEACH

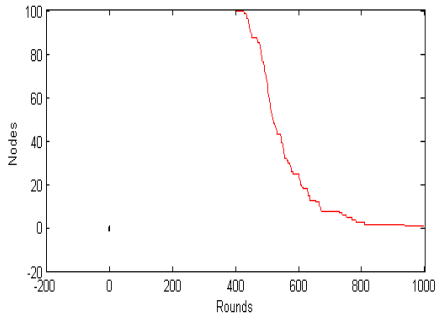

Fig 3: LEACH

8. CONCLUSION

In this paper an overview of the LEACH protocol is done with a mention to the different variants of the same and their advantages and disadvantages. Based on the drawbacks of LEACH a new enhancement of it called MMS-LEACH is proposed where different cluster head selection strategy is used. Simulation results shows that MMS-LEACH is more energy efficient than the LEACH.

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