Efficient Cluster Head Selection method with uniform clusters size to prolong the network lifetime of Wireless Sensor Network

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Abstract - *Energy is the main constraint for nodes powered by batter, in Wireless Sensor Network (WSN),* ***which can't be replace latter once deployed. To extend*** *the network lifetime, hierarchical routing is employed. In this paper we aim to improve network lifetime by using LEACH based protocol by considering residual energy and distance of nodes in WSN. We adopt dynamic clustering with dynamic selection of cluster heads in first round and static clustering with dynamic selection of cluster heads from second round. One more reason for network to die early is unbalance cluster size, to handle that number of nodes in the cluster is fixed to a predefined value. The protocol has been simulated in NS2 and results show improvement in energy efficiency i.e. Improved network lifetime, throughput, less packet drops and packet delivery ratio when compared to LEACH.*

Key Words: LEACH, Clustering, Routing Protocol, etc…

1. INTRODUCTION

Wireless Sensors Networks (WSNs) consists of small nodes having limited sensing, computation, and wireless communications capabilities. The distributed nature and dynamic topology of Wireless Sensor Networks introduces very special requirements [3] in routing protocols that should be met. Routing is the most challenging issue and direct concern to energy in WSN comparable with ad hoc and cellular network. Clustering technique [2][3] for routing in WSN is considered most suited because of its characteristics such as energy-efficient, scalable, lower latency, etc. Clustering is a process in which nodes are grouped into clusters; each cluster is controlled by a cluster head. This clustering approach improves the efficiency of data relaying by decreasing number of nodes required to forward data.

Cluster heads consumed more energy due to its role in collecting, removing redundancy, compressing and forwarding the data from cluster to the base station, while remaining nodes only sense the data in the environment and forward it to its cluster head, hence saving more energy. This situation gives rise to unbalanced energy consumption, which causes more drain of energy from cluster heads than cluster nodes in random fashion.

Unequal distribution [3][4] of nodes in the clusters may lead to overload some cluster heads and die soon, leaving the network partitioned. To solve this problem, we restrict clusters with fixed number of member nodes.

Because of the above disparities, several new routing mechanisms have been developed and proposed to solve the routing problem in WSNs. A high efficient routing scheme will offer significant power cost reductions and will improve network longevity. Finding and maintaining routes in WSNs is a major issue since energy constraints and unexpected changes in node status (e.g., inefficiency or failure) give rise to frequent and unforeseen topological alterations.

The WSNs may be used in a variety of everyday life activities or services. The common application of WSNs is monitoring. The WSN is deployed over a region in order to monitor some phenomenon. A practical use of such a network could be a military use of sensors to detect enemy intrusion. A similar area of use may be the monitoring of the air pollution, where the WSNs are deployed in several cities to monitor the concentration of dangerous gases for citizens.

A WSN may be used for forest fires detection to control when a fire has started. The nodes will be equipped with sensors to control temperature, humidity and gases, which are produced by fire in the trees or vegetation.

An important area of use is the healthcare sector. This area the WSNs may offer significant cost savings and enable new functionalities that will assist the elderly people living along in the house or people with chronic diseases on the daily activities.

Moreover, the use of WSNs on agriculture may benefit the industry frees the farmer from the maintenance of wiring in a difficult environment.

2. RELATED WORK

TL-LEACH (Two-Level Hierarchy LEACH)[3] is a proposed extension to the LEACH algorithm. It has two levels of cluster heads (primary and secondary) instead of a single one. Here, the primary cluster head in each cluster communicates with the secondary cluster head, and the corresponding secondary cluster head in turn communicate with the nodes in their sub-cluster. Data fusion can also be performed here as in LEACH. In addition to it, communication within a cluster is still scheduled using TDMA time-slots. The organization of a round will consist of first selecting the primary and secondary cluster heads using the same mechanism as LEACH, with the a priori probability of being elevated to a primary cluster head less than that of a secondary node. Communication of data from source node to sink is achieved in two steps: Secondary nodes collect data from nodes in their respective clusters. Data fusion can be performed at this level. Primary nodes collect data from their respective secondary clusters. Data-fusion can also be implemented at the primary cluster head level. The two- level structure of TL-LEACH reduces the amount of nodes that need to transmit to the base station, effectively reducing the total energy usage.

LCTS (Local Clustering and Threshold Sensitive) [9]: It combines the advantages of LEACH and TEEN [5] in terms of short transmission delay and threshold based data gathering. The base station does cluster-head selection. LS-LEACH (Lightweight Secure LEACH) [11] is improved secure and more energy efficient routing protocol Authentication algorithm is integrated to assure data integrity, authenticity and availability. Furthermore, it shows the improvement over LEACH protocol that makes it secure and how to make it more energy efficient to reduce the effect of the overhead energy consumption from the added security measures. It provides security measures to LEACH protocol after indicating the source and limitation of nodes. Also, we develop security measures to protect wireless sensors and the communications from possible attacks without compromising the network performance. For instance, securing LEACH protocol against denial of service attacks while maintaining its performance. Furthermore, the protocol assures that only the authenticated nodes are allowed to join and communicated in the network. At the other hand, we mitigate the overhead cost from the security measures applied to avoid compromising the network performance.

Sec-LEACH [12] proposes some creative modifications to LEACH protocol. It shows how to invest the key pre-distribution scheme to secure node-to-CH communications. The main idea is to generate a large pool of keys and their IDs at the time the network is deployed, and then each node is assigned a group of these keys randomly. Also each node is assigned with a pair-wise key, which shares with the BS; these keys are used during node-node and node-Base Station communications. This algorithm provides authenticity, confidentiality, and freshness for node-to-node communication. The number of nodes does not impact the security level; actually it depends on the size of the key group assigned for each node according to the total size of the key pool [12].

3. LEACH PROTOCOL

Low-Energy Adaptive Clustering Hierarchy (LEACH) [7][8] is one of the clustering based hierarchical routing protocols. It is used to collect data from wireless network. In the network, hundreds/thousands of wireless sensors are dispersed that collects and transmit data. In these sensor nodes the cluster head's are elected. Because sensor nodes have low energy source and battery cannot be replaced once deployed, the chances of node death scenario is more. So we require LEACH protocol to increase the lifetime of network.

LEACH protocol uses random selection cluster head selection and cluster formation. Here the energy is evenly distributed by rotating the cluster head in every round. LEACH protocol is divided into 2 phases:

1) Set-Up phase: Set-up phase includes cluster head selection and cluster formation.

Cluster head selection algorithm: In this phase, the nodes are randomly dispersed in a network. Each node takes a self-governing decision whether to become a cluster head for current round or not. Here every node will generate a random number between 0 and 1. If the number is less than threshold value, then node is cluster head for the current round. Threshold is given by

$$T(n) = \frac{p}{1-p\left(r \bmod \frac{1}{p}\right)} \quad if\ n \epsilon G \quad ----- \quad (1)$$

In the above equation (1), the parameters are:

p - optimal percentage of CHs in each round.
r - current round.
G - is set of nodes, which have not been elected as CH in (1/p) rounds.
Cluster formation: After cluster head selection, each node broadcasts advertisement (ADV) message using (CSMA/CA) MAC protocol. The near-by nodes send join request to cluster head. It follows a TDMA schedule to set-up and transmission and to assign separate time slots to each of its cluster members
2) Steady-state phase: This phase consists of transmitting data from cluster members to cluster head during allotted time slots. The cluster head aggregates data and forwards to base station.

4. PROPOSED APPROACH

4.1 Network Model

The network architecture for proposed approach is based on the following assumption:
1) Base station is located at the center of sensor field.
2) Sensor nodes are energy-constrained and have same initial energy.
3) All nodes are capable of becoming cluster head.
4) All sensor nodes are aware of the base station location.
5) Sensor nodes are static.
4.1 Proposed Algorithm
The proposed algorithm consists of two phases:
1) Set-up phase
Cluster head selection
Cluster formation
2) Steady state phase
Data transmission
Subsequent round Cluster head selection.

Set-up phase
Cluster head selection: In first round the cluster head is selected using random generation number. Here every node will generate a random value using random function. The node with highest random value is selected as cluster head.
b. Cluster formation: The cluster head sends (ADV) messages to all the nodes. Based on (RSS) received signal strength the cluster members send JOIN_REQ. The CHs create a TDMA schedule by which each member will get particular time to broadcast.

2) Steady state phase:
Data transmission: Here all CMs sense data and transmit it CHs. Next other information's such as residual energy, distance to Base station etc. Then the CHs will aggregate the data and calculates the energy.
Present Cluster head status: Here we proceed with second round of cluster head selection. The cluster head is selected based on the residual energy and distance to the base station.
Check the residual energy of individual nodes in the cluster.

If E_res > E_avg_of_cluster
Then set the current node as CH
Else check other node's residual energy
End

The distance is calculated using standard Euclid distance formula only if there is tie between nodes in their residual energy. The residual energy is measured after the 1st round.
E_res= current energy after 1st round -Initial energy of the cluster.
Using these two parameters i.e distance and residual energy, next cluster head is selected.

5. SIMULATIONS AND ANALYSIS

5.1 Simulation Environment

To analyze the performance of the LEACH with improved LEACH, we evaluate in NS2 simulator. The proposed algorithm is compared with LEACH and Results show increase in throughput.

5.2 Result Analysis

Throughput: Throughput is how much data receiver receives in bits/sec. The throughput of proposed approach is more compared to LEACH and LCTS protocol as shown in figure (1).

Energy: The Improved leach consumes less energy compared to LEACH and LCTS protocol as shown in figure (2).

Packet delivery ratio (PDR): it is the ratio of number of packets sent and number of packets received by the receiver. The PDR of proposed approach is higher than LEACH and LCTS protocol as shown in figure (3).

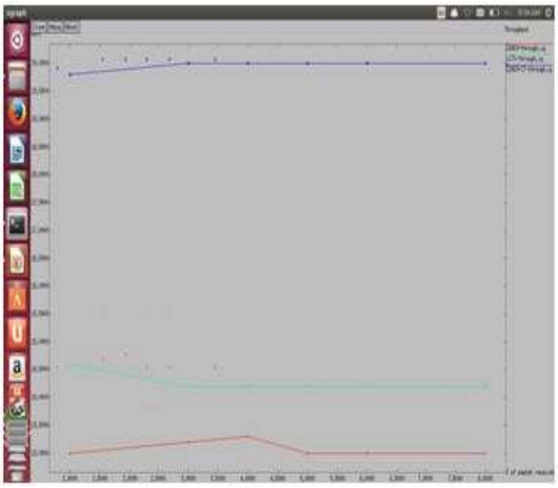

Fig-1. Throughput at sink node

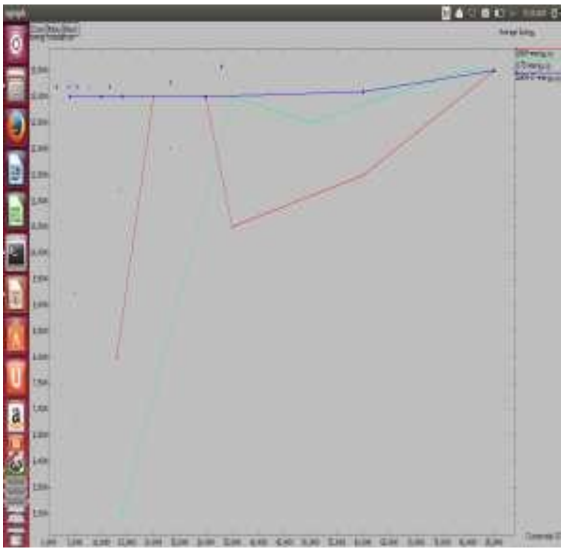

Fig-2: Average energy consumption against the cluster head

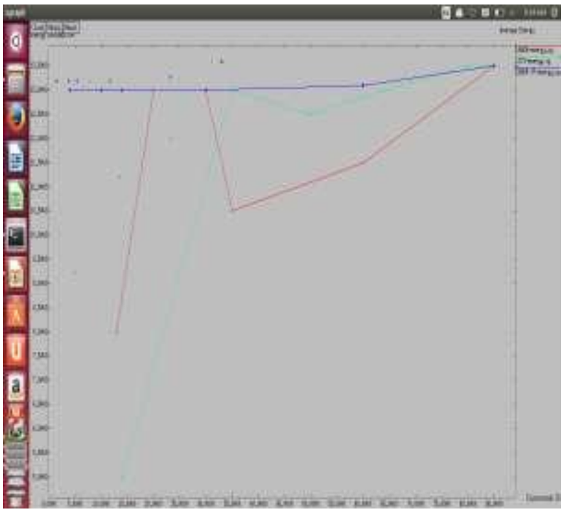

Fig-3: Packet delivery ratio

6. CONCLUSIONS

Paragraph The results of this paper show improvement in energy efficiency, throughput, less packet drops and packet delivery ratio when compared to LEACH. This paper is compared with other two protocols LEACH and LCTS. The proposed hierarchical routing protocol increases the number of packets received at the sink by adapting the technique of dynamic clustering with dynamic selection of cluster-heads at first round and static clustering with dynamic selection of cluster heads from second round. The cluster-head selected in consequent rounds is decided based on the residual energy and distance to the base station. Simulation results show that, this algorithm is much more efficient then other algorithms.

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