Improved Energy Efficient Cross Layer based Adaptive Threshold Routing Protocol for WSN

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Abstract: The wireless sensor networks have sensors running on low batteries. Clustering is one of the approaches used to achieve this objective. It involves selection of optimal cluster head among the set of nodes which aggregate the data from the nodes and forward it to base station. Clustering is the technique designed by the researchers to increase their lifetime. Increasing their lifetime is the major area of research these days so that they can work for longer duration of time and decrease the deployment cost of the network. This study presents a modification to the existing clustering scheme to increase the network lifetime. Both the existing and proposed clustering schemes were implemented in network simulator 2.35 and their performance was evaluated based on number of alive nodes, throughput and remaining energy of the network. The better values of these parameters help us to conclude that the proposed scheme outperforms the existing scheme. The paper discusses various clustering techniques which focus on selection of cluster head in the optimal way.

Keywords: WSN, Clustering, Energy efficiency, network lifetime, data aggregation.

I. INTRODUCTION

Wireless sensor network is the collection of wireless nodes that are often randomly deployed in a targeted area over vigorously changing environments. These nodes can sense, process, and forward data to neighbouring nodes and base station (BS). Moreover, these small devices have limited capabilities such as small memory, low computation, low processing, and most importantly small power unit (usually equipped with batteries). The sensor nodes are scattered over a large geographic area containing hundreds of nodes to monitor a target region. As the sensed data has to be forwarded to BS for further necessary action, therefore routing becomes important for transferring of data from node to node or BS efficiently [1–4].

In WSN, to efficiently utilise the available resources especially battery, different hierarchical techniques have been proposed. The goal is to obtain energy efficiency and maximize network lifetime. In hierarchical routing, clustering is the most widely used technique to achieve these goals. Clustering schemes by design eliminate the redundant messages in formation of efficient clusters and intelligent selection/reselection of the CH. Hierarchical network structure often makes a two-level hierarchy, in which the cluster heads are placed at the upper level, and the lower level is for member nodes. The lower level nodes periodically send data to their respective CH. The cluster head then aggregates that data and forwards it to BS. In literature, researchers have proposed various clustering protocols, but issues such as optimizing energy efficiency and load balancing require further research.

This paper also describes a clustering protocol that focuses on improving the lifetime of the

network. Section II of this paper describes the literature review of the related techniques of the clustering. Section III presents the proposed protocol. Results have been discussed in section IV of this paper and paper has been concluded in the last section.

II. LITERATURE REVIEW

A modified cluster-head selection algorithm based on LEACH (LEACH-M) was proposed in [5]. Based on distributed address assignment mechanism (DAAM) of ZigBee, both residual energy and network address of nodes were taken into account to optimize cluster-head threshold equation. Furthermore, by leveraging a cluster-head competitive mechanism, LEACH-M successfully balanced the network energy burden and dramatically improved energy efficiency. The simulation results in NS-2.35 show that the proposed algorithm can prolong the network lifetime, minimize the energy consumption, and increase the amount of data received at base station whether region is in a $100 \times 100m2$ or in a $300 \times 300m2$.

The present paper [6] proposes two algorithms using an approach that combines fuzzy c-means and ant colony optimization to form the clusters and manage the transmission of data in the network. First, fuzzy c-means is used to construct a predefined number of clusters. Second, we apply Ant Colony Optimization (ACO) algorithm to form a local shortest chain in each cluster. A leader node is randomly chosen at the beginning since all cluster nodes have the same amount of energy. In the next transmission, a remaining energy parameter is employed to select leader node. In the first algorithm, leader nodes transmit data in single hop to the distant base station (BS) while in the second the ACO algorithm is applied again to form a global chain between leader nodes and the BS. Simulation results show that the second proposed algorithm consumes less energy and effectively prolongs the network lifetime compared respectively with the first proposed and the LEACH algorithms.

This paper [7] represents a comprehensive scientific review of the role of evolutionary intelligence in sensor networks and its implications for this important part of engineering applications. This paper discusses the theoretical, mathematical and practical application of evolutionary computing with the use of evolutionary algorithms and the improvements resulting from the application of evolutionary intelligence in sensor networks. The content of this paper will review the most important of the evolutionary intelligence from principles, algorithms and applications. The problems facing the types of sensor network has been solved using evolutionary algorithms. After reviewing the evolutionary intelligence and its details in the sensor network, a performance evaluation is presented in the paper at the end of each of the targeted areas of the sensor network. This performance evaluation represents the measure of the quality of improvements provided by evolutionary intelligence in sensor network field with graphical analysis studies to demonstrate the effect of evolutionary algorithms on the sensor network.

This research article [8] presents a hybrid cluster head election for WSN based on firefly and harmony search algorithms. The contributions of the proposed protocols are (1) two level cluster head election strategy. In the first stage harmony

search algorithm is used to determine initial set of energy efficient cluster head nodes that are sufficiently separated from on another by certain optimal distance. Then tentatively elected cluster head nodes are refined by firefly algorithm by considering the parameters such as node density, cluster compactness and energy to be consumed. Sometimes nature inspired optimization techniques may end up in early convergence and to avoid such problems, cluster head election scheme is divided at two levels. (2) a refined cluster formation strategy is designed where a normal node has privilege of joining to cluster head node either based on distance based metric or based on residual energy of cluster heads. This process of cluster formation helps in reduced energy consumption. The presented protocol is compared with some of the well-known clustering protocols such as LEACH, LEACH-C, EOICHD, and simple firefly based routing protocol based on the evaluation metrics such as number of alive nodes, energy consumption of network, number of packets received by Base Station, First Node Dead, Half Node Dead and Last Node Dead. Implementation is carried out using Network Simulator (NS 2.34) and results show that proposed hybrid cluster head election scheme outperforms the mentioned routing protocols.

In this work [9], the authors give deep insight into the problem of disproportionate energy consumption and aim to improve the network load balance and increase the network lifetime by applying efficient distributed clustering method with the help of a mobile sink. The proposed scheme named Energy Balanced Distributed Clustering Protocol (EBDCP) guarantees to transmit the sensed data to the base station within the tour deadline with the aid of a mobile sink. For this purpose, an efficient sojourn point determination algorithm has also been proposed. The simulation results prove that the proposed scheme performs significantly better than the existing works in terms of the energy distribution in the network, clustering overhead, residual energy of the network, number of alive nodes and network lifetime.

In this paper [10], a routing protocol is proposed for the networks which are heterogeneous and are based on the adaptive threshold sensitive distributed energy efficient cross layer routing protocol. The concept of weighted probability is used to assign the CH (Cluster Head) of the network cluster. The proposed algorithm is simulated, tested and compared with previously established routing protocols and has shown enhanced results and prolonged network lifespan. In the proposed protocol, a combination of the proactive and reactive network is considered for effective data transmission.

III. PROPOSED WORK

In the proposed work, we assume the topology of the clusters remain fix for entire network lifetime, only the role of cluster heads will be rotated in the network. Once clusters have been formed in the network, each node will first send its remaining energy and distance to the base station to the respective cluster head. Cluster head after receiving the data from the cluster members, will schedule the nodes according to maximum remaining energy and minimum distance from the base station. The member that tops the list will become cluster head for the next round, the member that is second in the list will become cluster head in the next round and so on.

Each cluster head will send the rotation schedule to the cluster members. When all the cluster heads have aggregated the data from the cluster members, they will send the data to the base station via cluster heads.

Each cluster head will make chain with other cluster heads. For formation of the chains, each cluster head will forward its remaining energy to the base station along with number of cluster members. Base station will compute the energy cost of communication with each cluster head. The leader will be the one having highest remaining energy and minimum energy cost. The next cluster head in the chain will be the one having local least distance to the leader and least communication cost with the leader. Base station will inform the chain information to all the cluster heads. Each cluster head will thus forward the data to the base station via the chain formed.

IV. RESULTS AND DISCUSSION

The proposed work as well as existing work were simulated in network simulator 2.35. The simulation was conducted in network area of 100 sq meters and a total of 100 nodes were randomly deployed in the network. The various simulation parameters used for the simulation are given in the table below:

Parameter	Value
Channel	Wireless
Number of Nodes	100
Network area	100 * 100 sq meters
Base station location	(0,0)
E_{elec}	50 nJ/bit
E_{da}	5 nJ/bit/message
E_{amp}	0.0013 pJ/bit/m^4
E_{fs}	10 pJ/bit/m^2
Packet Size	512 bytes
Initial energy	0.5 Joules
Energy factor of super node	3
Energy factor of advanced node	2

Table 4.1: Simulation Parameters

The parameters used to analyse the performance of the network were number of alive nodes, remaining energy of the network and throughput. While number of alive nodes and remaining energy of the network determine the lifetime of the network, the throughput defines the number of packets sent by the nodes to the base station.

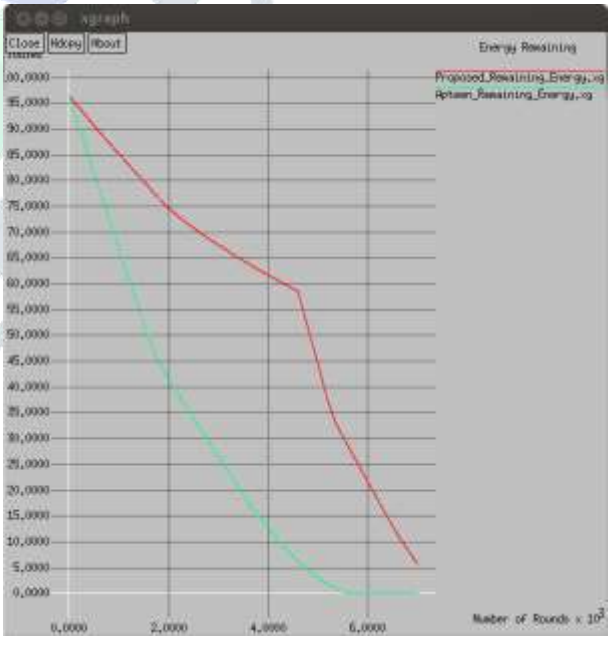

Figure 4.1 Comparison of Remaining energy of the network against number of rounds

The above figure shows the variation of average remaining of the network against number of rounds for the proposed as well as existing scheme. The green line shows the average

remaining energy for the existing scheme and red line shows the average remaining energy of the network for the proposed scheme. The remaining energy of the network goes to zero for the existing scheme after 5560 rounds. This means the network lifetime is 5560 rounds for the existing scheme. On the other hand, for the proposed scheme, even after 7000 rounds the remaining energy of the network was 5.7 Joules. This indicates higher network lifetime.

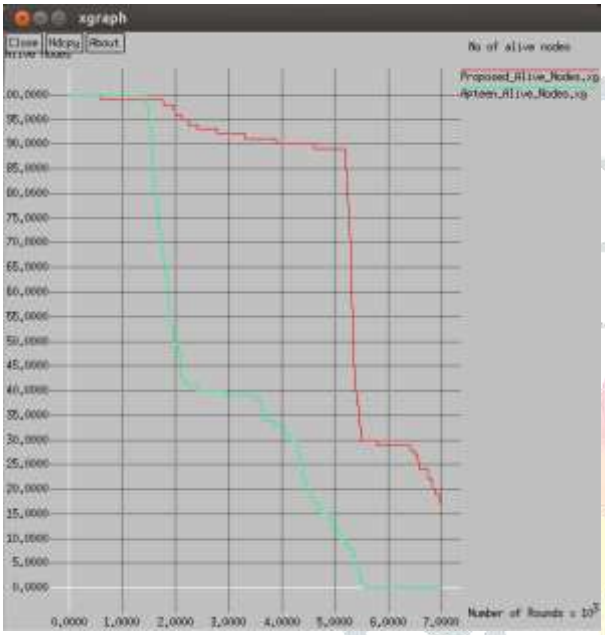

Figure 4.2 Comparison of Number of Alive nodes against number of rounds

This graph shows the number of nodes alive in the network against number of rounds for both the schemes. The network under the proposed scheme had 17 alive nodes at the end of 7000 rounds whereas with the existing scheme, the network went completely dead.

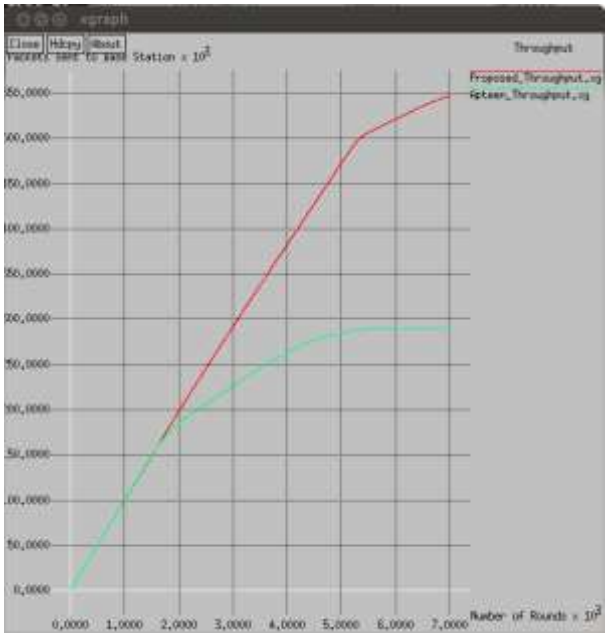

Figure 4.3 Comparison of Throughput against number of rounds

This graph shows the throughput of the network under both the schemes. Since the network with the existing scheme went dead at around 5560 rounds, the value of throughput goes constant after that. The proposed scheme has higher value of throughput since the number of alive nodes were more, so more number of packets were transmitted to the base station.

V. CONCLUSION

This study presents a modification to the existing clustering scheme to increase the network lifetime. Both the existing and proposed clustering schemes were implemented in network simulator 2.35. The proposed scheme showed that after simulation of 7000 rounds, 17 nodes were still alive. This is because in the proposed scheme, the cluster head rotation is avoided by creating the list of the cluster heads for the subsequent rounds. This also avoids the broadcasting of the advertisement packets by the nodes in every round. Therefore, the energy gets saved and nodes do not die earlier. Consequently, other two parameters also showed better

performance. Therefore, the better values of these parameters help us to conclude that the proposed scheme outperforms the existing scheme.

The wireless sensor networks provide a support to the internet of things networks these days. This clustering protocol can be applied for some IoT application in the future. The application can be agriculture oriented or disaster management application. Furthermore, the concept of mobile sinks can also be used in the future to enhance the network lifetime.

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