RELAY NODE BASED DATA TRANSMISSION TO AUGMENT LIFETIME OF WSN

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Abstract: Clustering the nodes in wireless sensor network (WSN) has been one of the recognized approaches when it comes to improving the lifetime of the network. Low Energy Adaptive Clustering hierarchical protocol (LEACH) is the origin for the clustering protocols for WSNs that allows the nodes to forward the data to their respective cluster heads which relays it to base station. This paper proposes a modification to existing Two-tier Era-based Clustering Energy-efficient Adaptive and Proactive Routing Protocol (TECEAP) in the context of choosing the relay nodes from each cluster to balance the load over the parent cluster head. The proposed and existing protocols were compared based on network lifetime, throughput and number of nodes alive. These parameters have shown an improvement over the existing scheme.

Keywords: WSN, network lifetime, LEACH, TECEAP, clustering

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 neighboring 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). 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 utilize 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. In hierarchical approaches, nodes are clustered into groups, and, by some criteria, a cluster head is selected that is responsible for routing.

In literature, researchers have proposed various clustering protocols, but issues such as optimizing energy efficiency and load balancing require further research. This paper presents various clustering techniques available in literature in next section. Section III presents the proposed clustering approach focused at improving the network lifetime. Results and conclusion have been discussed in Section IV and Section V respectively.

II. LITERATURE REVIEW

The proposed cluster-based routing protocol in [6] has a two-tier structure that combines the benefit of cluster-head distribution and chain-based routing to minimize cluster-head (CH) loss due to data aggregation and ROI to BS data transmission. Additionally, it uses an adaptive length of time for network reconstruction to maintain network adaptability with minimal network overhead through network awareness approach to maintain network connectivity. The results of the work have been compared to competing for energy efficient routing protocols that have probabilistic nature like LEACH and NEECP and routing protocols that tackle the same problem of relay nodes loss in far ROI to BS transmission. These results proved the advancement of TECEAP by showing about100% increase in network stability period, and the extremely low rate of network energy and node losses. The results also proved that in TECEAP, the ROI coverage is sufficiently preserved through the network lifetime.

Energy-Coverage Ratio Clustering Protocol (E-CRCP) is proposed in this paper [7], which is based on reducing the energy consumption of the system and utilizing the regional coverage ratio. First, the energy model is designed. The optimal number of clusters is determined based on the principle of “minimum energy consumption”, and the cluster head selection is based on the principle of “regional coverage maximization”. In order to balance the network load as much as possible, in the next iteration of cluster head selection, the cluster head with the lowest residual energy and the highest energy consumption is replaced to prolong the network’s life. The simulated results demonstrate that the proposed method has some advantages in terms of longer network life, load balancing, and overall energy consumption in the environment of a heterogeneous energy wireless sensor network.

This paper [8] focuses on an efficient CH election scheme that rotates the CH position among the nodes with higher energy level as compared to other. The algorithm considers initial energy, residual energy, and an optimum value of CHs to elect the next group of CHs for the network that suits for IoT applications, such as environmental monitoring, smart cities, and systems. Simulation analysis shows the modified version performs better than the low energy adaptive clustering hierarchy protocol by enhancing the throughput by 60%, lifetime by 66%, and residual energy by 64%.

In this paper [9], the authors propose an improvement of the reactive, anchor-based routing protocol with constrained flooding and dynamic clustering. They propose a new event-based clustering mechanism and a new dynamic clustering technique. This improvement results in reduced energy consumption and a higher number of packets processed successfully by the sink. Data collected by the mobile sink are shared to the end users through the IoT infrastructure. They conducted simulations using WSNet, an event-driven simulator for WSNs. The authors measured various performance metrics, such as the average residual energy, the number of active clusters, and the percentage of events processed successfully by the sink.

In this work [10], a novel residual energy–based distributed clustering and routing (REDCR) protocol has been proposed, which allows multi-hop communication based on cuckoo-search (CS) algorithm and low-energy adaptive-clustering–hierarchy (LEACH) protocol. LEACH protocol allows choice of possible cluster heads by rotation at every round of data transmission by a newly developed objective function based on residual energy of the nodes. The information about the location and energy of the nodes is forwarded to the sink node where CS algorithm is implemented to choose optimal number of cluster heads and their positions in the network. This approach helps in uniform distribution of the cluster heads throughout the network and enhances the network stability. Several case studies have been performed by varying the position of the base stations and by changing the number of nodes in the area of application. The proposed REDCR protocol shows significant improvement by an average of 15% for network throughput, 25% for network scalability, 30% for network stability, 33% for residual energy conservation, and 60% for network lifetime proving this approach to be more acceptable one in near future.

This article [11] proposes a hierarchical routing protocol based on the k-d tree algorithm, taking a partition data structure of the space to organize nodes into clusters. For the second aspect, the authors propose a reactive mechanism for the formation of CH nodes, with the purpose of improving delay, jitter, and throughput, in contrast with the low-energy adaptive clustering hierarchy/hierarchy-centralized protocol and validating the results through simulation.

This paper [12] presents a double cluster heads Adaptive Threshold-sensitive Energy Efficient Network based on ant colony (ADCAPTEEN). ADCAPTEEN optimizes the cluster head election method compared with APTEEN. It suggests that one master cluster head (MCH) and one vice cluster head (VCH) will be selected in each cluster. The double cluster heads (DCH) can co-work on data collection, fusion, transition, etc. To make routes more stable and energy efficient, this paper proposes a Multiple Adaptive Threshold-sensitive Energy Efficient Network based on Ant-colony (AMAPTEEN). It is the optimization of ADCAPTEEN. And CH selects intermediate node (IM_node) multiple times with ant colony algorithm per round in each cluster, and this way forms multiple route transmission data. Simulation in OPNET proves that compared with APTEEN, ADCAPTEEN reduces energy dissipation, improves node survival rate, and extends network life cycle. AMAPTEEN delays the time of node death, balances energy consumption, and extends network lifetime further operating in the same settings compared with ADCAPTEEN. The proposed two algorithms have good scalability, and they are suitable for large-scale network.

III. PROPOSED METHOD

The modified TECEAP protocol will follow the existing TECEAP for cluster formation algorithm at the beginning of network setup to select CHs that are in the lower tier of the network. The placement of the base station for the proposed M-TECEAP will be in the middle of the network.

1. Every node will generate a random number and compare it with threshold value. The optimal probability used every era is the current optimal probability of the sensor *s* to become a CH based on the current number of alive nodes and it is T(s,e) that can be calculated from equation as:

T(s,e)= (Popt(e)/(1-Popt(e) (e mod(1/Popt(e))))) * (Eres(s,e)/ E(s)) * (D(s,e) / N(e))

2. Each node is eligible to become a CH only if the random number is less than threshold value and the whole network is divided into clusters.

3. At the beginning of the era, the chain leader is selected based on the randomly generated value of each node in the clustering process, such that the leader at the beginning of each era is the CH with the maximum random number. Hence, this random number is used for both CH selection and Leadership Factor (LF) in the first set of rounds in an era.

4. The leader remains throughout this era until its energy reaches threshold energy level. Thus, it became an old leader. The old leader knows the LF of other CHs, since each CH calculates its *LF* every round and share it among other CHs in the data packets that are finally collected by that old leader. As a result, the old leader can select the new leader with the highest LF from the CHs whenever its residual energy becomes equal to threshold value to leave its leading role to that new leader with no chance to become a leader again during the rest of rounds in this era. Accordingly, the second set of rounds starts with the new leader.

5. Since the cluster heads already spend more energy in the data aggregation as equated to other network nodes. Thus, in the proposed M-TECEAP, we propose the concept that from each cluster one node will be put to sleep mode. The node will be the one which has minimum distance to the base station and highest residual energy.

6. The node will not take part in the sensing the data from the environment or data aggregation process. The node will only become active to when the leader of the CH chain receives all the data from the child CHs. The parent CH will forward the data to the base station via its relay node (the node which was put to sleep mode earlier).

IV. RESULTS

In this paper, we have implemented TECEAP as well as modified version for this in MATLAB. To create the sensor network we have used following parameters:

Parameter	Value
Network area	100 * 100 sq meters
Number of sensors	100
Location of base station	50,50
E_{elec}	50 nJ per bit
E_{fs}	10 pJ per bit per m^2
E_{amp}	0.0013 pJ per bit per m^4
E_{agg}	5 nJ per bit
Deployment Type	Random
Initial Energy	0.5 Joules
Energy Model	First order Radio Energy Model

Table 4.1: Simulation Parameters

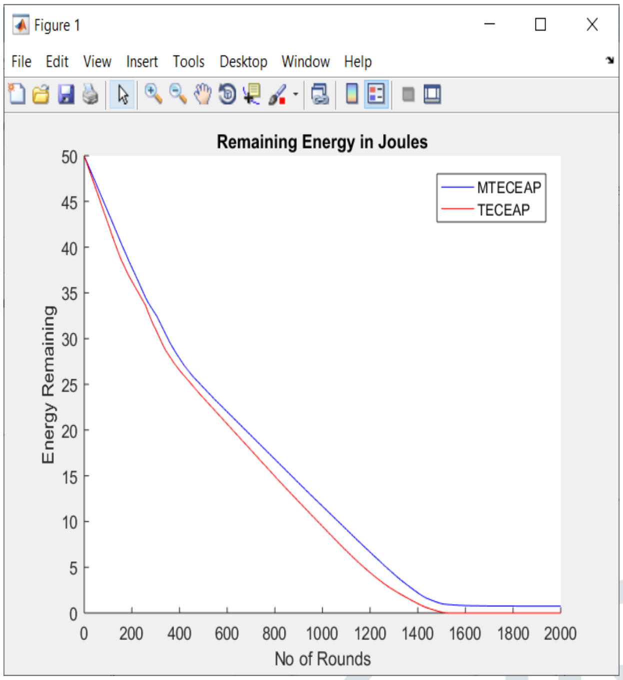

Figure 4.1: Remaining Energy Comparison

This figure shows the comparison of the remaining energy of the network versus the number of rounds. The total number of rounds for which the network ran was 2000. The network had total of 50 Joules of initial energy, each node having 0.5 Joules. The existing scheme drained out entire energy of the network at 1543 rounds while the proposed method had 0.75 Joules of energy left after 2000 rounds.

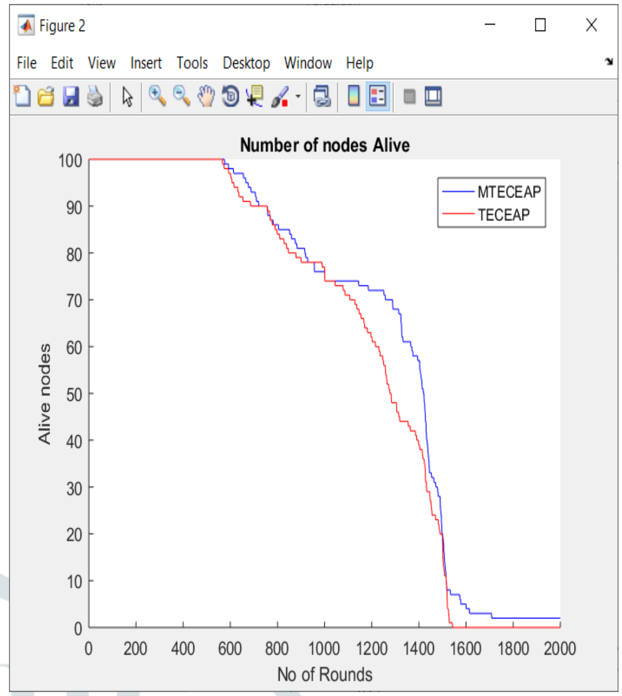

Figure 4.2: Number of nodes alive Comparison

This figure shows the number of nodes alive in the network for both the schemes. With TECEAP the number of nodes alive were 0 at 1543 rounds and with Modified TECEAP the network had 2 nodes alive after 2000 rounds of execution.

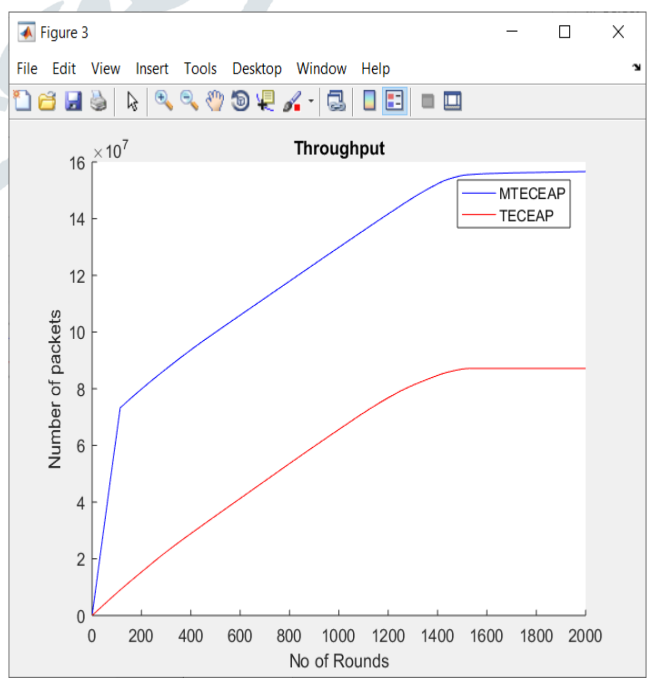

Figure 4.8: Throughput Comparison

The value of throughput achieved with both the schemes. The existing scheme had value of 8.71 * 10^7 packets that were delivered at base station while the proposed scheme got 15.53 * 10^7 packets delivered at the base station.

Parameter\Scheme	TECEAP	Modified TECEAP
Number of alive nodes after 2000 rounds	0	2
Throughput	8.71 * 10^7	15.53 * 10^7
Remaining Energy after 2000 rounds	0	0.75
Network Lifetime	1543 rounds	More than 2000 rounds

Table 4.2: Results Comparison

V. CONCLUSION

The proposed work was aimed at improving the network lifetime of wireless sensor network. In the proposed work, the forwarding of the data from the leader to the base station was suggested via relay nodes. The performance of the network was analyzed based on number of nodes alive, remaining energy and throughput. The proposed scheme allows the leader of the chain to forward the data to the base station via relay node which is the node from the cluster that has been put into the sleep mode. This reduces the load over the cluster head and therefore, the energy consumed is evenly distributed and results in improved network lifetime. Since the network has more alive nodes with the proposed scheme, therefore more nodes can forward the data to the base station. This leads to increased throughput of the network as well.

In future, work can be done by using the concept of mobile sink to gather the data from the cluster heads. This will also reduce the distance between the nodes and the sink, thereby leading to improved network lifetime.

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