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Energy Efficient Enhanced K-Means Cluster-based Routing Protocol for WSN

R. Renuga Devi and Dr. T. Sethukarasi

[1]*Research Scholar, Dept of Information and Communication Engineering, Anna University, Chennai, Tamil Nadu, India.*
[2]*Professor, Department of CSE, RMK Engg College, Chennai, Tamil Nadu, India.*

Abstract - *In recent years Wireless Sensor Networks (WSN) is getting popular in wide range of applications. WSN consist of many sensor nodes which are capable of sensing, computing and communicating facility. The main challenge in WSN is the energy constraint, which is still being addressed by many works. Due to their limited power, they need to be utilized carefully. The proposed algorithm is an energy efficient K-means clustering-based routing protocol that considers an optimal fixed packet size based on radio parameters and channel conditions of the transceiver. This protocol can minimize the energy consumption of each node thus maximizes the network lifetime as a whole. In addition to that varying power levels are considered during data transmission from cluster head (CH) to cluster member. Simulation results prove that our algorithm performs better than conventional K-means based energy aware clustering (KEAC) in terms of network lifetime and increases the overall throughput of the network.*

Key Words: **Wireless Sensor Network, Routing, Clustering, Energy efficiency, Network lifetime.**

1. INTRODUCTION

A wireless sensor network (WSN) consists of thousands of small size, low-power and energy-constrained sensor nodes. These nodes are deployed randomly in a field to sense the environment and transmit the required information to the sink node from where it reaches the end user. Sensor nodes are operated by batteries and deployed in remote areas which make it difficult to manually recharge and replace their batteries. Limited power of sensor node is one of the major concerns in wireless sensor networks. Sensor nodes in WSNs consume most of its energy in transmission and reception of packets from nearby nodes. Therefore, the design of an energy efficient scheme is a challenging issue for researchers. WSN use distributed sensor nodes to monitor various conditions of remote locations such as temperature, sound, vibration, pressure, motion and pollutants. A WSN is configured by sensor nodes equipped with sensing, computing and wireless communication capabilities. WSNs have many variants depending on applications and environments. Maintaining a long lifetime in WSN is important as limited and non-refilled battery are equipped in sensor nodes.

2. RELATED WORK

Low Energy Adaptive Clustering Hierarchy (LEACH) is the first and most popular cluster based routing protocol. Based on this, several routing protocols have been developed, each of them having different attributes and improvements primarily in the network setup phase. Among several routing protocols clustering schemes have been proved to be more efficient [1-2].

Based on previous works, a new routing protocol has been proposed in this paper to increase the energy efficiency of the WSN. Firstly, K-means clustering algorithm has been used to divide the nodes in the form of clusters. Secondly, unlike other routing protocols, optimal fixed packet size is considered according to the radio parameters and channel conditions of the transmitter and receiver [3], to decrease energy consumption of nodes. Then the total amount of energy required to transceiver the packet is calculated. The standard weight of the cluster is defined by the total calculated energy and the average distance of the corresponding cluster nodes toward its cluster center. Finally, the node with weight almost equal to the standard weight within a cluster becomes the cluster head for that particular round. Moreover, two different transmission levels are considered for the communication from cluster head to the base station and cluster members [4]. This increases the energy efficiency of the system. Many cluster based routing algorithm have been presented in [5], and [6] provides solutions to the Energy efficient and Energy-balanced routing. In K-Hop Overlapping Clustering Algorithm (KOCA) [7], author deals with the idea of how to overcome overlapping in multi-hop clustering for WSN. The authors propose an algorithm to generate overlapping clusters which can cover the entire network field with a specific degree of average overlapping.

3. PROPOSED ALGORITHM

Here the system model includes a Base Station (BS) and several sensor nodes within sensing, computing and communicating abilities. Nodes in WSN are classified into cluster heads (CH) and cluster members (CM). CMs sense the environment and transmit data to the CH. CHs aggregate the information and transmit it to the BS. It is the common and centralized approach of clustering protocol in which CH selection takes place in base station and the

elected CHs are announced to all the CMs of the cluster. This requires huge amount of energy due to the reduced control overhead in sensor nodes.

Hence we propose an algorithm which uses K-means clustering for cluster formation and considers optimal packet size as a decision variable for selection of CH. Always short packets suffer from greater overhead whereas longer packets experience higher loss rates. It has been identified that network throughput can be optimized by varying packet lengths with channel conditions. Here, the proposed scheme considers optimal packet size to reduce energy consumption and improves lifetime of the sensor nodes in WSN. The proposed algorithm consists of three phases:

3.1 Initialization Phase

This is the first phase in which BS broadcast a message as initialization request (IRQ) to all sensor nodes within WSN. After receiving IRQ message, sensors response with an initialization reply message (IRP) to the BS. The IRP message consists of energy of nodes and their current location.

3.2 Cluster Formation Phase

K-Means is considered to be the simplest unsupervised clustering algorithm used for clustering. This algorithm divides the data set into K clusters and value of K in this case is calculated using following equation. The resulting clusters have more intra-cluster and less inter-cluster similarity. This routing algorithm includes several iterations and steps

Step1:

Calculate K, the desired number of clusters using the following formula

$$K = \sqrt{\frac{N}{2\prod}} \sqrt{\frac{e_{fs}}{e_{mp}}} \frac{F}{x_{BS^2}}$$

Where N is number of sensor nodes, F is the dimension of the given network field, e_{fs} and e_{mp} are amplification parameters and x_{BS^2} is average distance of all the sensor nodes to the base station.

Step 2:

Calculate the distance between every sensor node to every cluster centers using Euclidean distance, and assign each point to the closest center.

$$Dist = \sqrt{\sum_{i=1}^{N} X_{diff}}$$

Where Dist is the distance of node to cluster center, X_{diff} is the difference between the co-ordinates of sensor node i and cluster center

Step 3:

Now we can identify the new cluster center by calculating the mean value of all sensor nodes in the corresponding cluster.

Step 4:

Repeat step 2 with the new centers. If the cluster assignment sensor nodes changes, repeat step 3 else stop the algorithm.

3.3. Cluster Head Selection Phase

In order to select CH for each cluster, we generate two weight functions as

$$W_{ni} = c1 * E_{ni} + c2 * D_{cci}$$

$$W_{std} = c1 * E_{total} + c2 * AvgD_{cc}$$

where i=1, 2, 3, 4....N and c1 and c2 are constants, W_{ni} is the weight of each node with in a cluster, E_{ni} is the residual energy of node i, D_{cci} is the distance of node i to cluster center, W_{std} is the standard weight of a node which can be considered to become cluster head, E_{total} is the amount of energy required to transmit and receive the information to average distance of all the nodes to the cluster center within a cluster. These two weights are compared for each cluster and the node with weight almost equal to standard weight is considered to be the CH for that particular round. The CH information is now broadcast to each sensor node in a cluster by BS and this way their routing tables are updated.

4. SIMULATION AND REULTS

Simulation is carried out in MATLAB with some basic assumptions. All sensor nodes including base station are considered to be static once deployed.

- Sensor nodes are homogeneous in terms of its initial energy assignment.
- There exists only one BS in network.
- Decoding energy, trailer length, Delay and retransmission mechanism are not considered here.

Simulation parameters and values are as follows

Table -1: Simulation parameter

Simulation parameters	Values
Sensing area (m2)	100x100
Electronics Energy (E_{elec})	50 nJ/bit
Data Aggregation Energy(EDA)	5nJ/bit/signal
Initial Energy of Node(E_{init})	0.5J
Number of Nodes (N)	100
Position of BS (X , Y)	(100,175)

Following chart represents the total network energy conserved during for each round. It is clear that energy consumption of proposed method Enhanced KEAC (EKEAC) is much less than KEAC and thus it outperforms the conventional KEAC.

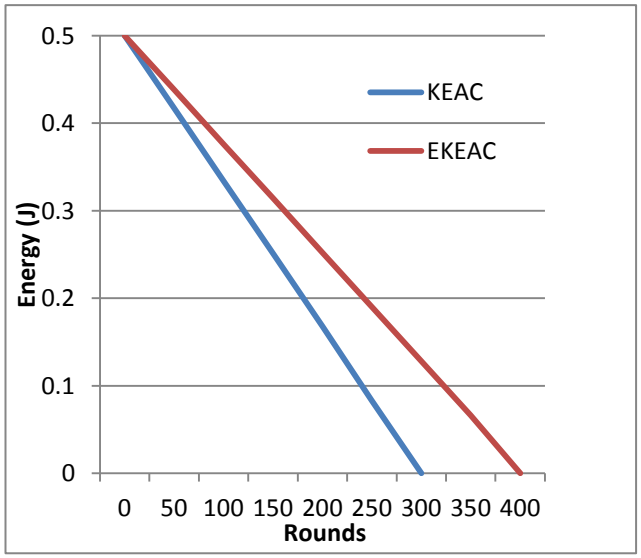

Chart -1: Network Energy Conservation

Network life time can be measured in varying methods. Some of them are first node failure, network partition, and last node failure. Here we measure network lifetime with respect the dead of first node failure. Chart 2(a) and 2(b) show the number of rounds at which first node and half of the sensor nodes in the network die out respectively. From this, it is obvious our EKEAC increases longevity of the network and also results in minimum energy consumption of individual nodes.

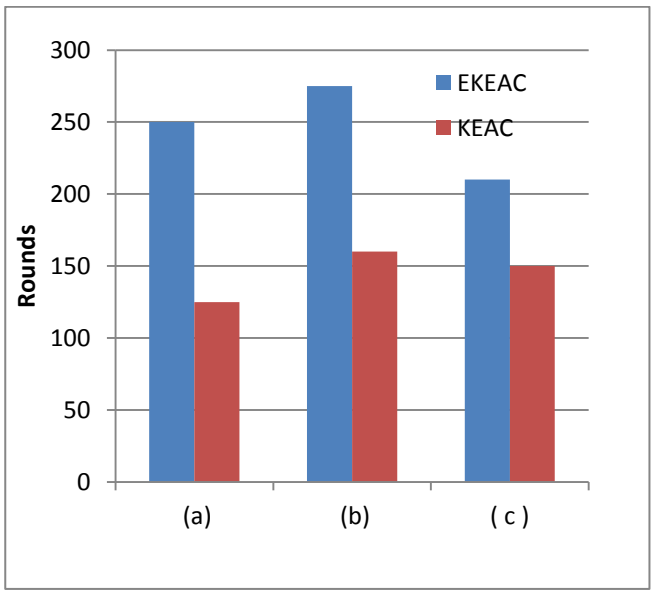

Chart -2: (a) First node dead, (b) Half node dead, (c) Throughput of network

The throughput of the whole network is also shown in chart 2(c) for both routing algorithms which is the total number of packets sent to the total number of packets received by the BS at the end of the simulation. From Chart 2(c), it is seen that the throughput of EKEAC is higher than KEAC.

5. CONCLUSION

In this paper, a cluster based routing protocol with enhanced method of using K-means routing for clustering (EKEAC) has been proposed. This proposed routing protocol calculates the total amount of energy required for each packet which is used along with average distance of the nodes to cluster center to compute a standard weight. The simulation results indicate that the proposed scheme has high energy conservation and increased network lifetime.

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