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Energy Efficient and Mobility Based Clustering for MANET

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Abstract

Mobile Ad Hoc network is a self-configure dynamic network which consists of mobile nodes. MANET has some restriction like, limited battery power, limited bandwidth, mobility in nature and frequent topology changes. These constrains make the environment very challenging. To manage the mobile nodes entire network can be partitioned into clusters. Each cluster has a head node which plays the leader role. The head node consumes more battery power than the other nodes in the network. The proposed work present an energy efficient model and a mobility model, which plays the primary role in electing the suitable cluster head and also introduce a zonal based energy consumption model which utilize the energy of the nodes in right way. The simulation result shows that the proposed work perform well than the existing algorithm.

Keywords: *MANET, Energy, Mobility and Cluster Head.*

1. Introduction

MANET is a self-configure network which prone to frequent topology changes due to the mobility nature. These type of network has constrains like, limited battery power, limited bandwidth, dynamic in nature, etc., which makes the area very challenging. Though it has constrains these types of network suits for some applications like, military, vehicle, games, entertainment and also where the physical implementation of network is not possible. MANET consists of mobile devices which have wireless link between two nodes which are in same transmission range. Mobile Ad Hoc network protocol can be classified as flat routing and hierarchal routing. In flat routing all the nodes in the network has a same role in packet forwarding.

In hierarchical routing certain nodes are given importance in packet forwarding. Clustering fall under hierarchical routing in which the mobile nodes are grouped into clusters and each cluster will have a leader node called cluster head node which is responsible for resource allocation. All the cluster head will form a virtual backbone and cooperate with each other for packet routing.

A node which is common for two clusters is called as gateway node. Due to the dynamic nature any node in the cluster can leave the cluster or can join as a new member to any existing cluster. The new comer or the leaving node may cause the change the existing cluster head and also the structure of the cluster. Hence, the cluster head role is not permanent and any node in the cluster will get a chance to act as a cluster head at any time. Clustering plays important role in minimizing the routing overhead since, the change in the local cluster need not be updated for the entire network. In spite of the advantages, clustering has some constrains. Every cluster has a cluster head which plays the role of local coordinator, which consume more energy than the ordinary nodes [2]. The main objective of any clustering algorithm is to maintain the existing structure of the cluster as much as possible [3].

2. Related Work

2.1 HID

The HID [2] is based on the degree of nodes assumed to be the number of neighbors of a given node. During the cluster head election, every node in the network, broadcast its unique ID. When the neighbor receives the message and computes its degree and broadcasted to its entire neighbor. The node with the highest degree becomes cluster head. Due to the lack of upper bound on the number of nodes in the cluster, the cluster head in HID cluster head changes very frequently In addition, as the number of nodes in a cluster is increased, the throughput drops and system performance degrades.

2.2 LID

The Lowest-ID (LID) algorithm [3] in which each node is assigned a distinct ID, a node which has lowest ID becomes a cluster head. This procedure is repeated for remaining node until either each node is selected as a cluster head or cluster member. Even though it gives better result than the HID the main drawback of the LID is, it partiality towards nodes with smaller IDs nodes, which may lead to the battery drainage of certain nodes in the network, and it does not attempts to balance the load uniformly across all the nodes. Also, it does not consider the qualification of a node.

2.3 LCC

LCC [4] Least Cluster Change Algorithm ,which allows minimizing cluster head changes that occur when 2 cluster heads come into direct contact. In such a case one of them will give up its role and some of the nodes in one cluster may not be members of the other cluster heads cluster. Therefore, some nodes must become cluster head while causing a lot of re-direction because of the propagation of such changes across the entire network.

2.3 DCA

Distributed clustering Algorithm [5]] in which each node has a unique weight instead of just the nodes ID, these weights are used for the selection of cluster head. Node will compare its weight with its neighbor's weight and if it is highest it announces itself as a cluster head, otherwise it joins to neighboring cluster. During the execution of the algorithm the network topology of DCA does not change. Thus, it suites only for static network than the dynamic network like Ad hoc where the mobility is high.

2.4 WCA

In WCA [6] weight is determined based on multiple variables. Combined weight is calculated with degree difference, sum of distance, running average speed and time during which a node performs a cluster head. Among the weight smallest weight is chosen as cluster head. "Global minima" way is used for searching for the node with the smallest weight in network. For this way, it is necessary for all nodes to know the weights of the nodes in the entire network. It takes long time to configure cluster head, generating lots of overhead. Here the election procedure is not periodic and is invoked as rarely as possible. Each cluster head can ideally support only pre-defined threshold nodes.

In this proposed energy efficient and mobility based cluster algorithm which maintain stable clustering and elect the suitable node as a cluster head. The rest of the paper is organized as follows: Section III deals with the new energy and mobility model followed by clustering procedure and Section IV about discuss the simulation study of the proposed work and section VI gives concluding remarks.

3. Propose Work

3.1 Mobility Model

In wireless network a source node will relay the packet to the destination through the intermediate nodes. Any time link between source node and destination nodes can break. Link breakage in unavoidable for the following reasons:

- Due to the node mobility
- Limited energy power

Most of the proposed clustering algorithm uses GPS for finding the mobility of a node in a network. In the proposed work a new method called mobility prediction method is introduced in which node movement is predicted by using the information of the host which are stored in the Cluster Member table (CMT) by a cluster head. The information's are gathered while receiving hello messages from the cluster members. Ever nodes in the network start broadcasting hello messages. When a node receives a hello message from its neighbor, it copies the information in its Neighbor Table (NT). After the neighbor identification the clustering procedure starts. Clustering procedure is discussed in section 3.3. Each cluster head will record the member information's in CMT, which are used for the further process.

NID	P(x,y)			M	D	BP
	T1	T2	T3			

Fig 1.Cluster Member Table (CMT)

3.2 Energy Efficient Model

Node mobility is unavoidable in dynamic environment like MANET. But energy constrains can be managed. An ordinary node in MANET will consumed energy for the following state:

- Sending the Packets
- Receiving the packet
- Listing to the network or during idle.

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Certain amount of energy is drained when a node forward or receive a packet from the neighbor. It also consumes energy when it is idle because a node should be always ready to receive packets from the neighbor. The energy consumed during the idle time is almost equal to the energy of receiving traffic.

When the MANET nodes are clustered, consumption of energy differs from ordinary node to cluster head node. A cluster head node consumes more energy than the other nodes. Cluster head is responsible for:

- Forwarding Packets
- Receiving packets.
- Allocating resources to the members

When a node starts dropping the energy, it can't serve any more in the cluster as neither a head nor the forwarding node. To efficiently handle the energy, the proposed work use a method called zonal based sleep-Wake up method in which, the node which is not located in routing circle will be switched off to save energy. By doing so, a node can serve its energy instead of listing to the network i.e., idle state.

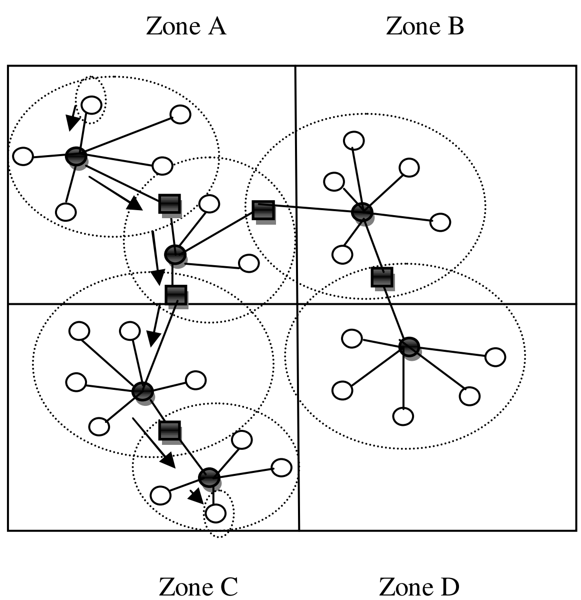

Fig 2. Sample Packet forwarding

When a source node wants to send a packet to a destination node which is in the other zone, it finds the intermediate node to send the packet. In fig 2, the source node is in zone A and the destination node is in zone C. The forwarding nodes are in both A zone and in C zone. The nodes in zone B and zone D does not involve in packet forwarding they are in idle state. These nodes can be switched off to serve energy. Switching off doesn't mean that they are death, the transmitter will always listen to the signals of the neighbors and also the zones A and C nodes which are not involved in packet forwarding can be switched off.

3.3 Preprocessing stage

The main objective of the preprocessing stage is to minimize the setup time of the initial cluster. To obtain the objective we divide the simulation area into zones. The Preliminary version of this Zonal Based Distance is presented in [12].

3.3.1 Cluster Election Algorithm

Electing a suitable cluster head is depends upon the parameters like, Distance (D), Mobility (M) and Battery Power (BP). By considering the above parameters a Quality Factor (QF) is calculated. When a node broadcast the hello message it sends the QF of its own which is compared by the neighbor nodes and finally a node with smallest weight is elected.

Step 1: Calculating Distance

The distance is taken from the corresponding zonal distance tables. These tables consist of the distance between the cells in the network.

Step 2: Calculating Mobility

The mobility of a node is calculated using the procedure illustrated in section

Step 3: Calculating Battery Power

Batter power is calculated as

$$R_e(t) = I_e(t) - C_e(t)$$

Where:

$R_e(t)$: Remaining energy of the node at time t.

$I_e(t)$: Initial energy of the node at time t.

$C_e(t)$: Current energy of the node at time t.

Step 4: Transmission Range

Transmission range will be same for the entire node in the network.

Step 5: Estimating Quality Factor

$$QF = F_1D + F_2M + F_3\,R_e + F_4T$$

For each node QF is the combined weight value of the nodes. The QF value is the node weight which is broadcast to the neighbor nodes that are within its own transmission range. These weight measures express the nodes ability to become a cluster head. Each node compare its weight value with its neighbors and the node with smallest value will announces itself as a cluster head. The entire neighbor will join the cluster as a cluster member for the newly elected cluster head.

4. Simulation Parameter and Result

Our model EECA is evaluated via simulations using NS-2 [9]. We have simulated 150 nodes in an area of 1200m X 1200m. The number of nodes taken is 150.The network scenario is illustrated in Table 1.

Table 1. Simulation Parameters

Parameter	Meaning	Value
Speed	Speed of the node	18 m/sec
R	Transmission range	250 m
Time	Duration of simulation	150 sec

To evaluate the proposed work we have taken the well known clustering algorithm WCA. We used various metrics like, average number of cluster head, number of re-affiliation and number of dominant set updates towards transmission range and speed to achieve the goal effectively.

4.1 Transmission Range vs Average number of clusters

This metric is divided on the number of partition into which the entire network is divided. From the Fig.3 we observe that the average number of clusters decreases with increases in transmission range. This is due to the variation in transmission range. From the curve we can observe that the EECA and WCA are same when the transmission increases.

4.2 Transmission Range vs Number of re-affiliation

This refers to a cluster member changes its cluster head. Due to the mobility a node can either move out of the cluster or join as a new member. In both a cases the corresponding node changes its cluster head. Fig 4 shows the re-affiliation with respect to the transmission range. In the proposed EECA the re-affiliation is minimized when compared to WCA.

4.3 Transmission Range Vs Number of dominant set updates

The dominant set updates takes place if a node moves out of the cluster head. Higher overhead occurs if there are more dominant set updates. Fig.5 shows the number of dominant set updates degreases because the nodes stay within their cluster in spite of their movements. Fig: 3 Average-No-of cluster vs Transmission Time.

4.4 Speed vs Average number of clusters

We can see form the Fig.6 shows the number of clusters remain stable whatever the speed may be. WCA and EECA both are almost same still EECA has less number of updates than the WCA when compared with existing.

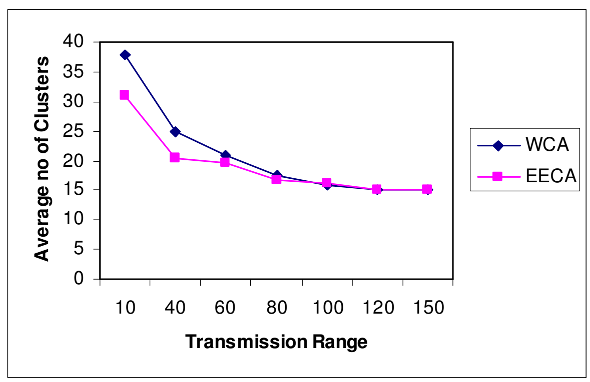

Fig: 3 Average-No-of cluster vs Transmission Time

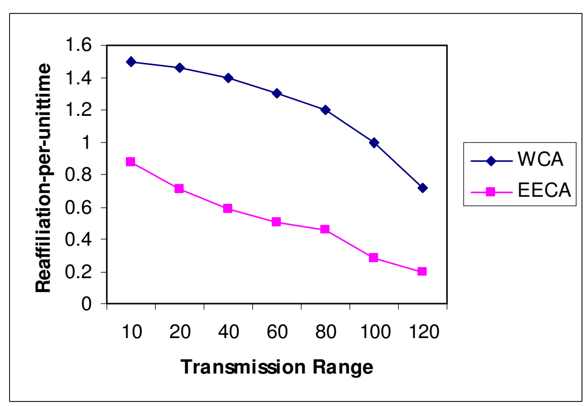

Fig: 4 Reaffiliation /unit time vs Transmission Time

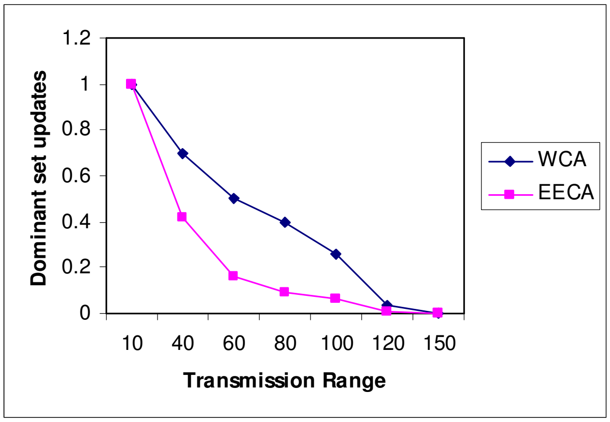

Fig: 5 Dominant set updates vs Transmission Time

4.5 Speed vs Number of re-affiliation

From the Fig. 7 shows the re-affiliation with respect to speed. We observed that the re-affiliation increases when the speed of the node increases. This is because the node leaves the current cluster and joints the new one very faster as the speed increases. EECA performs well when compared to WCA.

4.6 Speed vs Dominant set updates

The cluster head updates are referred as dominant set updates of cluster head. This says the overall stability of the cluster. Fig 8 shows the result for number of dominant set update vs speed. Increase in speed make increases in dominant set updates because when speed increases the nodes will change their place very frequently.

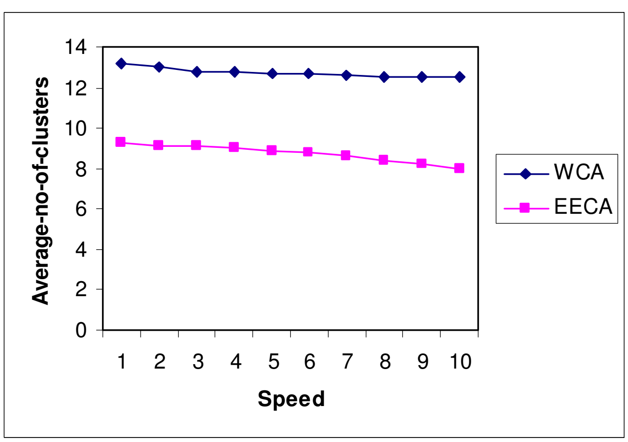

Fig: 6 Average-No-of cluster vs Speed

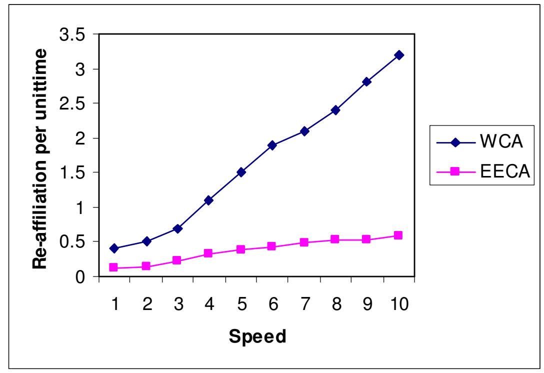

Fig: 7 Reaffiliation /unit time vs Speed

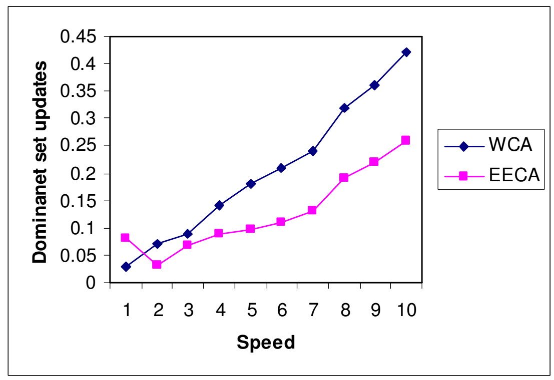

Fig:8 Dominant set updates vs Speed

5. Conclusion

The proposed Energy Efficient and mobility based Clustering Algorithm for MANET, gives more preference to the parameters which decides the cluster head. Mobility, Batter power, Distance and Transmission power are the parameters taken to decide the cluster head. A new energy model is proposed, which aims to handle the energy efficiently and also mobility of a node is handled well. Objective of this paper is to make the network more stable by means of energy and mobility. Moreover, in this work we have a preprocessing stage which sets the network environment before the nodes are entered. This helps the quick set up time for the clusters. The outperformance of the proposed work is evaluated under NS-2 and the outcomes are compared with a well known algorithm WCA and the proposed one gives good results and ensures the stability of the clusters and cluster heads.

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