MPBCA: Mobility Prediction Based Clustering Algorithm for MANET

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ABSTRACT

MANET is a multi hop wireless network in which the mobile nodes are dynamic in nature. Each node in the network has a limited bandwidth and minimum battery power. Due to this challenging environment the mobile nodes can be grouped to achieve better stability. Grouping the mobile nodes is called clustering, in which a leader node is elected to manage the entire network and which is responsible for resource allocation. Mobility causes the network instable, which leads to link failure. We have proposed a mobility prediction based clustering algorithm in which the mobility pattern of the nodes is observed and given importance in electing cluster head. Simulation study is carried out and the performance of the proposed work is compared with the WCA and proved that the proposed model performs more than the WCA.

General Terms

Wireless Network, Mobile Ad Hoc Networks

Keywords

MANET, Clustering, Cluster head.

1. INTRODUCTION

MANET is a self-configure multi hop wireless network in which absence of infrastructure, Limited bandwidth, Dynamic in nature, unpredictable link failure, etc., perturbs the efficient network services [10]. In MANET environment the mobile nodes have a wireless link between them through which the communications are made. The links are unbreakable when they are in same transmission range. Due to the dynamic nature, a node moves from one place to another which causes link failure and unstable network. Hence, to achieve a stable environment there should be a hierarchy among nodes which guarantee the stability of the environment. This can be achieved through clustering where ever mobile nodes can be grouped according to some criteria. Grouping of nodes are called as clustering.

Cluster concept was used to address path stability and scalability problem [1]. Clusters are formed by grouping mobile nodes and assigning a special role to a single node called cluster head. Resource allocations, local coordination, inter and intra cluster communications are the responsibility for the cluster head node. Apart from cluster head node cluster will have gateway node and ordinary nodes. Gateway nodes are the one which are common to more than one cluster and remaining nodes are considered as ordinary nodes in the cluster. Clustering makes the network environment easy to maintain and manage. When the nodes are clustered, local changes need not be update for the entire network. Only the changes are made for the corresponding cluster. This will reduce the overhead. Though the cluster has many advantages they to have some disadvantages. Cluster head being the network communication hotspot have a propensity to drain the battery power rapidly when compared to the ordinary nodes [2]. The objective of cluster maintenance is to preserve as much of the existing clustering structure as possible [3] and also it should not change cluster configuration drastically and often when a few nodes are moving [11].

2. Related Works

HID [1] is based on the degree of nodes assumed to be the number of neighbors of a given node. During the election, nodes broadcast its unique ID in the network. Every node computes its degree and broadcasted to its entire neighbor and the highest degree node becomes cluster head. Due to the lack of upper bound on the number of nodes in the cluster, the cluster head in HID changes very frequently. In addition, as the number of nodes in a cluster is increased, the throughput drops and system performance degrades.

The Lowest-ID (LID) algorithm [5] 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 is, it partiality towards nodes with smaller IDs which may lead to the battery drainage of certain nodes, and it does not attempts to balance the load uniformly across all the nodes. Also, it does not consider the qualification of a node.LCC [6] 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. Distributed clustering Algorithm [7] 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.

In WCA [8] 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 paper we propose a MPBCA algorithm in which we choose a cluster head by considering various parameters like distance, mobility, battery power and Transmission Range. We have proposed a mobility prediction method which is one of the primary factors for stable network. The rest of the paper is organized as follows: Section II is a related work and section III deals about the working of the proposed MBCA. Section IV has the simulation study of the proposed work and section V gives concluding remarks.

3. PROPOSED WORK:MBCA

Stability of any network is achieved when there is no mobility. But MANET is a dynamic wireless network in which the mobility is unavoidable. Node mobility denotes the movement of hosts inside the network. Mobility can't be avoided but can be predicted. When the node movement is predicted earlier, the cluster head node could be selected depending upon the mobility prediction method. Hence, the node which is comparatively stable could be selected as a cluster head. This will ensure the network stability. Most of the proposed clustering algorithm uses GPS for finding the mobility of a node in a network. In this work we introduce a new method called mobility prediction method, which observe the speed of a node and find the mobility pattern.

The proposed work has 3 procedures. The first procedure A is to initially set the network area followed by procedure B which illustrate mobility model and finally procedure C is to elect the cluster head.

3.1.PROGEDURE A : *PREPROCESSING STAGE*

Preprocessing stage in which the network area is divided into zones. Further, each zone is again portioned into cells where each zones consists of 16 cells. Each cell will be assigned a place value p(x, y). This place value will be the node position. To divide the network area into zones and cells we used geometric progression method. In Fig.1 we have depicted the 4 zones in a network namely, Z(A), Z(B), Z(C) and Z(D) and sample nodes placed in each node with its node id's.

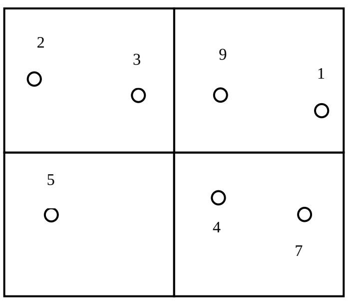

Fig.1 Nodes positions in the Zones

Fig 2 which illustrate the zonal Z(A) place values p(x,y), which is further used for finding the distance of any two nodes.

A(7,1)	A(7,2)	A(7,3)	A(7,4)	A(7,5)	A(7,6)	A(7,7)	A(7,8)
A(6,1)	A(6,2)	A(6,3)	A(6,4)	A(6,5)	A(6,6)	A(6,7)	A(6,8)
A(5,1)	A(5,2)	A(5,3)	A(5,4)	A(5,5)	A(5,6)	A(5,7)	A(5,8)
A(4,1)	A(4,2)	A(4,3)	A(4,4)	A(4,5)	A(4,6)	A(4,7)	A(4,8)
A(3,1)	A (3,2)	A (3,3)	A(3,4)	A(3,5)	A(3,6)	A(3,7)	A(3,8)
A(2,1)	A (2,2)	A (2,3)	A (2,4)	A(2,5)	A(2,6)	A(2,7)	A(2,8)
A(1,1)	A (1,2)	A (1,3)	A (1,4)	A (1,5)	A(1,6)	A(1,7)	A(1,8)

Fig.2 Place Value of nodes in Zone A

3.2.***PROCEDURE B :*** *MOBILITY MODEL*

The mobility is predicted by using the information of the host which is stored in the Cluster Member Table (CMT) by a cluster head. The information's are gathered while receiving hello messages. Ever nodes in the network start broadcasting hello messages to find their neighbors. When a node receives a hello message from its neighbor, it copies the information in its Neighbor Table (NT). All the nodes in the network find their neighbor using the hello message. After the neighbor identification the clustering procedure starts. Clustering procedure is presented in procedure C, which brief the steps involved in electing cluster head node. After the clusters are formed, each cluster head will record the member information's in CMT, which are used for the prediction of the mobility.

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

Table 1.Cluster Member Table (CMT)

Using CMT table a cluster head find the average speed of a node. When the first hello message is received from a cluster member *i*, the place value $p(x_i, y_i)$ of the node during time T1 is recorded in CMT. The same procedure is followed for consecutive hello messages. The average speed of the node is calculated using the information, and a node with minimum speed will identified as a slow moving node and given preference for the role of cluster head. In this work we have taken only three hello message for observing the mobility pattern of a node. This is because we assume that a node can't stay in a same position or nearby position for a long time.

3.*3* PROCEDURE C: *CLUSTER HEAD ELECTION*

Each cluster will have a leader node which we call as cluster head node, which is responsible for the corresponding cluster. Cluster head node is the one which assign the work and takes the in-charge of resource allocation to its entire member node. Electing a suitable cluster head is a primary task. To elect a proper cluster head MPBCA, has taken the Distance (D), Mobility (M), Remaining Battery Power (R) and Transmission Range (T). 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

Distance is calculated using a zonal based distance method, in which the place value p(x, y) of every node is used. A table called Zonal Distance Table is constructed for each zone using the place value. In our model we have four zonal distance tables.

Step 2: Calculating Mobility

The mobility of a node is calculated using the procedure B.

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

Using these quality factors each node will estimate its own weight and broadcast it to the neighbor nodes that are within its own transmission range. These weight measures express the nodes ability to become a cluster head.

$$`QF = F_1D + F_2M + F_3 R_e + F_4T$$

For each node QF is the combined weight value of the nodes. 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. PERFORMANCE ANALYSIS

3.3. Simulation Parameters

To show the outperformance of MPBCA is evaluated via simulations using NS-2 [9]. The results of MPBCA is compared with well know clustering algorithm WCA. We have simulated 150 nodes in an area of 1200m X 1200m. Initially we use geometric progression method to divide the simulation area into zones. We get four zones where each cells are assigned with a place values. The speed of a node is set as 18m/sec. The network scenario is illustrated in Table 1.

Parameter	**Meaning**	**Value**
N	Number of nodes	150
X x Y	Size of the network	1200 X 1200
Speed	Speed of the node	18 m/sec
R	Transmission range	250 m
Time	Duration of simulation	150 sec

Table 2: Simulation parameter

3.4.Performance Metrics

Main objective of the proposed work is to maintain the stability of the cluster. To evaluate the cluster stability 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.

1. Transmission Range vs Average number of clusters:

This metric refers to the number of partition of the nodes as clusters. 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 ZBCA and WCA are same when the transmission increases. ZBCA performs well even when the transmission range is less. When the transmission range is increased both the algorithms performs the same.

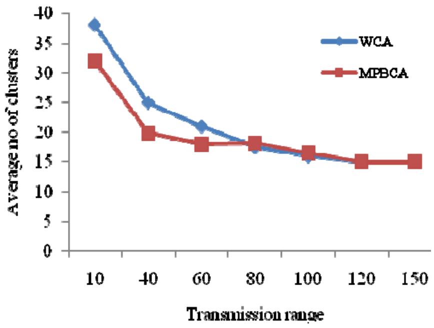

Fig.3. Average no of Clusters vs Transmission range

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 MPBCA the re-affiliation is minimized when compared to WCA. Comparatively the proposed is good than the existing

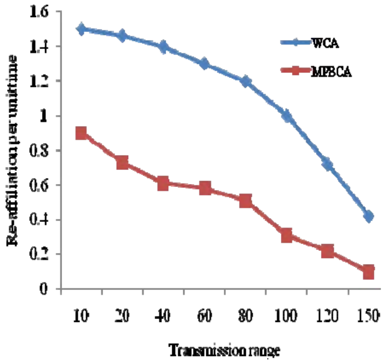

Fig.4. Re-affiliation/unit Time vs Transmission range

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.

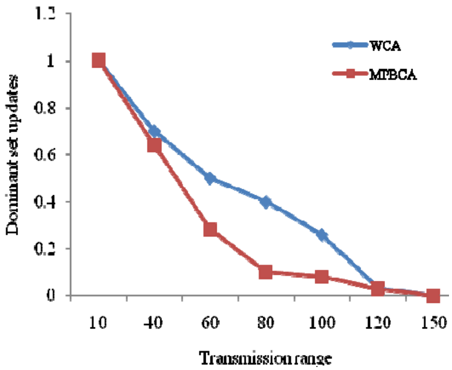

Fig.5. Dominant Set Updates vs Transmission Range

4. Speed vs Average number of clusters:

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

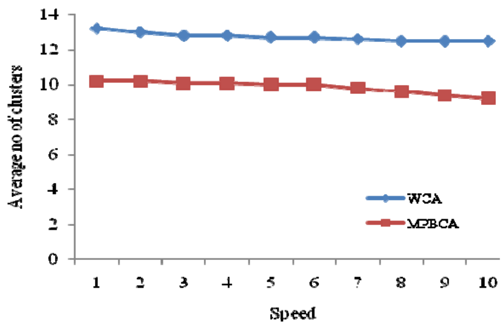

Fig 6 Speed vs Average no of Clusters

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. MPBCA performs well when compared to WCA.

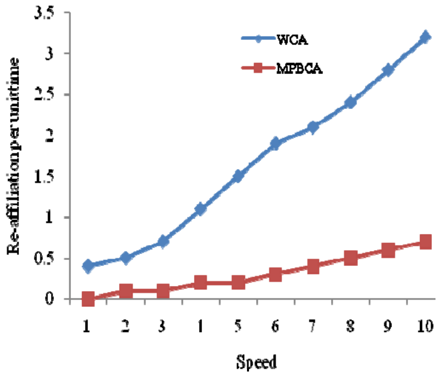

Fig.7 Speed vs re-affiliation /unit time

6. Speed vs Dominant set updates.

Node movement causes information 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

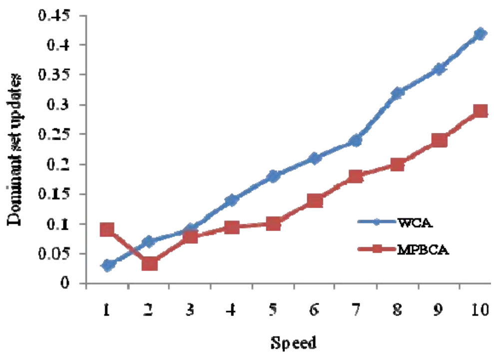

Fig.8 Speed vs Dominant set updates

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5. CONCLUSION

The proposed Mobility Prediction Based Clustering Algorithm for MANET (MPBCA) gives more preference to the parameters which decides the cluster head. Mobility, Remaining Batter power, Distance and Transmission Range are considered to decide the cluster head. Objective of this paper is to make the network more stable. To achieve the objective, the cluster heads is chosen according to the mobility prediction method. A new mobility prediction method is proposed, in which the mobility pattern of the nodes are observed. Slow moving nodes are then identified and preference is given to the cluster head role. Mobility prediction method uses the information's which are gathered during the hello messages. 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 MPCA is evaluated under NS-2 and the outcomes are compared with a well known algorithm WCA and MPBCA gives good results and ensures the stability of the clusters and cluster heads.

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