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Relaxing Weighted Clustering Algorithm for Reduction of Clusters and Cluster Head

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Abstract: Adhoc clustering in MANET is to divide mobile nodes into different virtual groups. Mobile nodes are allocated geographically adjacent in the cluster. Clustering is done by some rule specific in the network. In this paper, we have concentrated to modify weight based clustering algorithm to improve the performance in this wireless technology. By slight improvement in existing weight based clustering algorithm [1] reduction in cluster as well as cluster head can be observed through experiment. Proposed Algorithm specifies relaxing the weight criteria for isolated cluster head nodes in range of other cluster head as well as reconsidering the nodes in the range which is already participated in cluster formation. Reconsidering the participated node again in clustering formation could help in creation of better cluster, forming better routes as well as in conserving the cluster head energy.

Keywords: Adhoc Networks, Clustering, Clustering Algorithms, NS-2, Weight Based Clustering, Energy Efficient Clustering.

1. INTRODUCTION

Mobile adhoc network is self configuring wireless nodes which communicate in transmission range. Flat and hierarchical topologies are available for arranging the mobile nodes in the network. Mobile adhoc network is infrastructure less network which follows the wireless topology in routing and data forwarding. Mobile node acts as router as well as gateway for other nodes. Clustering is a familiar technique and the cluster formation every group of node is formed together and the arranged in one group which is used to prevents the flood of unnecessary packets and avoids wasting network bandwidth. In this technique, a large network can be divided into several sub-networks with only a few cluster heads maintains the local information. In the flat topology packet flood can be observed but with hierarchical topology control of data packets and messages can be controlled. Hierarchical topology saves network bandwidth, saves energy for mobile nodes, provide better availability of routing option and provide spatial reuse of resources to increase the system capacity. It also has drawbacks such as scaling, stability of the network, dynamic topologies etc. Mobile nodes have many attributes such as mobility, power, compatibility etc. All the static and dynamic behavior must be considered in designing hierarchical topology.

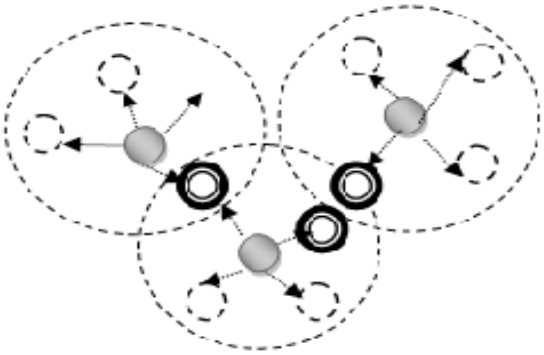

Fig 1:- Example of Cluster Network


Cluster Head (CH)


Gateway node (CN)


Cluster member (CM) / Ordinary Member

This clustering techniques are working with three important aspects which shown in Fig 1. CH plays with superior power in the intra-cluster network which elected by the other member nodes. CH serves the other nodes and perform important role in routing of information from one node to other. Information passes through the cluster head.
Any of the routing techniques such as DSR, AODV, TORA, and DSDV etc can be used in exploring the routes from one node to another. In cluster based routing protocol the route messages are graceful by the following method:

Source → Cluster Head→ Gateway → Cluster Head → Gateway → ⋯ → Destination.

Information can be passed internally to the cluster or to the external cluster better known as intra cluster and inter cluster routing. Clustering mainly of two types overlapping and non-overlapping. Mixed of clustering is also possible in the network. Cluster members can be of one hop or multi hop distance from the cluster head. Many terms such as cluster formation and maintenance, cluster member re-affiliation, ripple effect of clusters and cluster communication has been studied before. Cluster Formation is to invoke such method to find dominant set with cluster head which results in cost effective clustering. Any causes such as dead node, cluster member or cluster head movement results in cluster maintenance.
Moving of cluster member from one cluster to another results in cluster member re-affiliation. Reaffliation of member can cause ripple effect of clusters i.e. invocation of cluster formation.

Section II explains some related clustering algorithms and cost effective clustering criteria. Section III describes the proposed algorithm. Section IV deals with simulation environment and comparative results with the existing weight based clustering algorithms and the conclusion described in Section V.

2. RELATED WORK

The Ad hoc networks topology structure has classified into flat topology structure and hierarchical clustering structure. Due to the dynamic topology of ad hoc, the flat structure results are inefficient. After that, the researchers have proposed the hierarchical clustering structure for ad hoc networks. The clustering techniques can be classified as graph based and geographical based. A number of clustering algorithms have been proposed to choose cluster-heads based on the speed and direction, mobility, energy, position, and the number of neighbors of a given node. These efforts present advantages but also have some drawbacks, such as the high computational overhead for both clustering algorithm execution and update operations. To achieve cost effective clustering below criteria must be considered.

- Minimising re-election of Cluster head.
- Efficient method to find cluster head.
- Reducing the Reclustering or ripple effect by Reclustering.
- Scalable Clustering Scheme.
- Maintenance cost of clustering should be low.
- Load on the distributed nodes must be optimised.
- Network load and cost of communication must be low.
- Minimising the re-affiliation cost.
- Minimising the topology change in clustering.
- Mobility of the node must be considered.
- Power of CH node must be sufficient to serve other nodes.
- Selection of CH and Gateway node must be fast.
- Non Overlapping Structure for Spatial reuse.
- Cluster Size affects communication cost or delay the operation of communication. Greater cluster size have more cost than smaller cluster size.
- Decrease the node, Number of Clusters will be increased.
- Increase in Cluster Head, Increase Hop Distance for data forwarding.
- Form Stable Cluster or Find Stable clustering mechanism.

All above criteria cannot be achieve and considered as NP hard problem of clustering. Most clustering schemes are classified as follow: (a) Dominant set based clustering (b) Low maintenance clustering (c) Mobility aware clustering (d) Energy efficient clustering (e) Load balancing clustering and (f) Combined metrics based clustering. In this paper study of combined metrics based clustering has been presented. Weighted clustering algorithm is one of the combined metrics based clustering.

The **Weighted Clustering Algorithm** (WCA) [1] was originally proposed by M. Chatterjee et al. which obtain 1-hop clusters with one cluster-head. The election of the cluster-head is based on the weight of each node. This algorithm performs with four admissible factors for the cluster head election and maintenance. The four factors are degree difference (Dv), summation of distances (Pv), mobility (Mv) and cumulative time (Tv). Although WCA has proved better performance than all the previous algorithms, it is also has few drawbacks to know the weights of all the nodes before starting the clustering process and CHs rapidly Changing difficulties. As a result, the overhead induced by WCA is very high. The weight value associated to a node 'v' is defined as Wv = W1Dv + W2Pv + W3Mv + W4Tv
A CH algorithm finishes once all the nodes become either cluster head or a member of cluster head. A cluster head consumes more battery power than ordinary node. This algorithm depend few conditions i.e. the distance between members of CH must be less or equal to the transmission range between them. WCA assumption is that a node can support up to δ nodes for better MAC functioning.

WCA Steps for Cluster formation [1]

1. Compute the degree d_v each node v.
2. Compute the degree-difference for every node.
3. Compute the sum of the distances D_v with all neighbors.
4. Compute the average speed of every node; gives a measure of mobility M_v.
5. Compute the total (cumulative) time P_v a node acts as cluster head.
6. Calculate the combined weight W_v for each node $W_v = w_1\Delta_v + w_2D_v + w_3M_v + w_4P_v$.
7. Find min W_v; choose node v as the cluster head, remove all Neighbors of v for further WCA.
8 Repeat steps 2 to 7 for the remaining nodes.

3. PROPOSED WORK

In this section, weight based clustering algorithm has been studied and modified for reduction of cluster as well as reduction of cluster head. We will analyze two scenario of clustering where modification can result in efficient clustering as well as energy can be saved.

Scenario (a): Isolated cluster formation due to minimum weight selection among the nodes.

Step 7 of weighted clustering algorithm [1] could result in isolated cluster. Consider nodes arrangement in table 1. Weight has been taken arbitrary but similar situation also arises while executing in real environment or in network simulation. Range of nodes may or may not be same for this scenario. Assume maximum delta a node can support is (δ) 4.

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Node ID	Weight(Wv)	Nodes in range
1	4	3,4,5
2	3	5,7,6,8
3	7	-
4	8	-
5	9	-
6	12	2
7	10	2
	2	-

Table 1

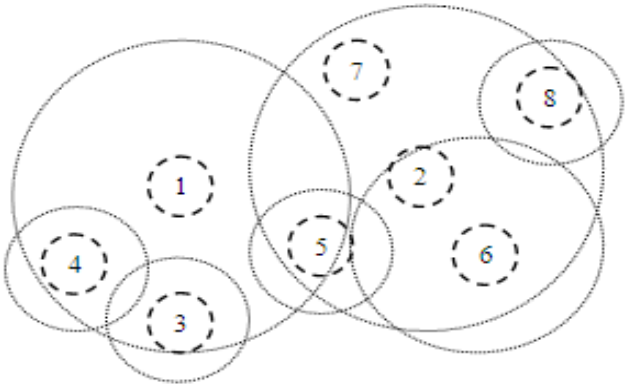

Fig 2:- Cluster architecture before cluster formation.

Running the WCA on above network structure, clustering shown in Fig 3 has been formed for cluster creation process. Cluster head, Member Nodes and gateway nodes are shown in Fig 3. Node_8 has the minimum weight and becomes the cluster head. It has no members in the range so it becomes an isolation node. Node_2 becomes the cluster head after Node_8 since it has more weight than the node_8.Node_1 becomes the next cluster head and node_3 and node_4 becomes its member. Similarly Node_2 serves node_5, node_6 and node_7. Node_8 has no neighbors in the range and hence become isolated cluster as shown in Fig 3.
We also assumed that cluster head can serve up to four nodes. In this case no cluster head is serving the maximum threshold. Here there are two problems isolated cluster head as well as maximum threshold has been not served. Both of the problems can be solved if relaxation is made in minimum weight criteria.

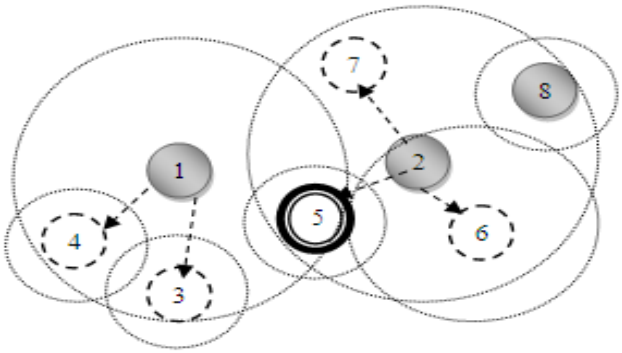

Fig 3:- Cluster Formation with weighted clustering algorithm

Relaxing the already formed isolated cluster head (Node_8) minimum weight criteria and including it in cluster formation again by checking that the cluster head (Node_8) has no neighbors associated and current cluster head node (Node_2) is under threshold, isolated cluster head node (Node_8) becomes member of the next cluster head (Node_2) selected. Since isolated cluster node (Node_8) is not serving any node so there is no need to be a cluster head. Isolated Cluster (Node_8) must be in the range of the next incoming cluster head (Node_2).It is not necessary that immediate node (node_2) with minimum weight in the range elect isolated node as member node. It may take time and turn of next minimum node could be late in cluster head election process due to minimum weight. It will be an exception in the network with minimum weight having no neighbors become a member nodes instead a cluster head. Now the cluster formed will be shown in Fig 4.

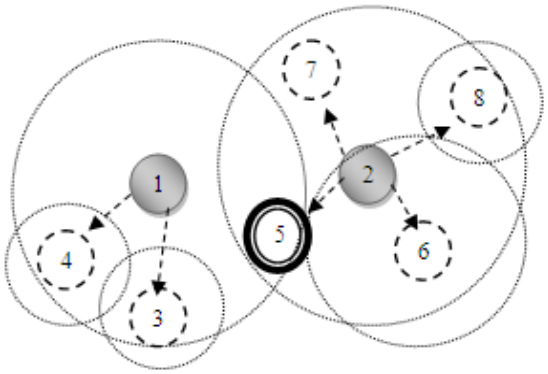

Fig 4:- Cluster Formation after relaxing the minimum weight criteria for isolated nodes.

Such adjustments in the network can help in minimizing the hop count while routing. It reduces the cluster head as well as number of clusters in the network. Less number of clusters in dense network reduces the hop count and intern traffic in the network which is already proven fact.

Scenario (b): Cluster Change of the ordinary or member node if its distance and weight is less than the newly selected cluster head node and become member of new cluster formed.

Energy consumption is more if the node distance is more in communication range. So to save energy already selected member node can be re elected in the cluster formation. Slight change in algorithm can help in achieving the task.
Each node can support maximum threshold to 4 nodes. Node_1 has minimum weight and become cluster head. Neighbor (node_3, node_4, node_8 and node_6) nodes become cluster member. After this cluster Node_7 becomes cluster head according to next minimum weight shown in Fig 5. Once cluster member become part of one cluster it cannot participate in the next cluster head election process but it can be in the neighborhood of other cluster head and it hears the request of cluster election procedure. Small calculation by this member node (node_4) while hearing Node_7 cluster head request can join the

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new cluster formed by node_7 cluster head. Node_4 need to check the distance of previous cluster head (node_1) to the new cluster head (node_7) that it's less or more. If node_4 has less distance from node_7 and node_7 can satisfy the maximum threshold as well as node_4 has more weight than Node_7, node_4 joins the cluster formed by Node_7 shown in Fig 6.

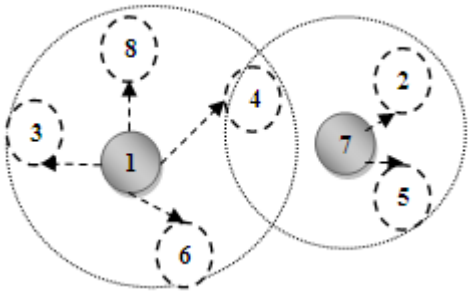

Fig 5:- Initial cluster according to weighted clustering algorithm

Node ID	Weight(Wv)	Nodes in range
1	1	3,4,6,8
2	9	7
3	10	1
4	8	7
5	9	7
6	5	1
7	4	2,4,5
8	12	-

Table 2

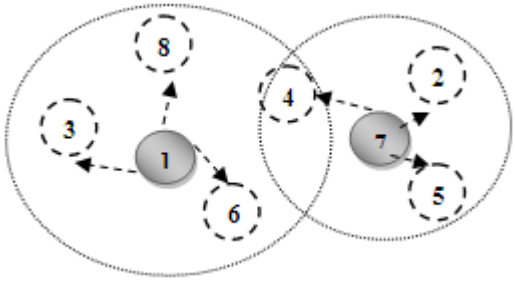

Fig 6:- Node_4 join the cluster formed by Node_7

4. SIMULATION ENVIRONMENT AND RESULTS

A. Introduction

Network Simulator 2 (NS2) is a discrete event simulator targeted at networking research. It provides support for simulation of TCP, routing and multicast protocols over wired and wireless networks. Currently DARPA, NSF and ACIRI support the development of NS. It contains three types of discrete event schedulers: list, heap and hash based calendar. NS2 also provides default implementations for network nodes, links between nodes, routing algorithms, transport level protocols and some traffic generators. Adding functionality to these objects can extend the simulator. NS2 also contains some useful utilities which include Tcl debugger used to debug Tcl scripts and it might become necessary if one is using large scripts to control a simulation. Tcl-debug is not however installed automatically with NS2 but it can be installed later. The major drawback of using Tcl-debug is that it is dependent on used Tcl version and also NS2 version.

B. Simulation Study

In simulation N was chosen to 30 nodes and arrange randomly with X and Y specified. Simulation has been performed with weighted clustering algorithm and weighted clustering after combining scenario (a) and scenario (b).

Parameters	Meaning	Value
N	No of nodes	30
X*Y	Simulation Area	650X500
R	Transmission Range	50-100
Mobility Model	Random Way Point	-
Duration	Simulation time	50Sec
MD	Maximum Displacement	300-400

C. Simulation Results and Discussion

Arrangement of thirty nodes has been done with specifying the coordinates on network simulator. Nodes have been distributed in range of 50 and 100. Weighted Clustering Algorithm has been implemented first; its arrangement in the network area is such that out of 30 nodes 20 nodes become the cluster head and correspondingly 20 clusters. Maximum threshold node to be supported is 4 but none of the cluster head serves maximum threshold. It could be because of arrangement of nodes. Further modified weighted clustering algorithm which includes scenario (a) and scenario (b) on the same network reduce the cluster head to 15 and correspondingly 15 clusters. Result will be variable since it depends on node distribution on the network. It could be possible that network doesn't have isolated node i.e. all nodes are in the range of each other. If the nodes are isolated and fall under scenario (a) definitely could result in reduction of cluster. Scenarios (b) don't reduce the cluster head and cluster size. Its logic is only for better energy conservation or for saving the energy for cluster head since in this case cluster member changes its cluster head identification. Fig 7 and Fig 8 shows the comparison between WCA and WCA with addition of scenario (a) and scenario (b). Since the network is designed randomly such scenarios are likely to take place. This research work has been focused on such issues and further modification to the algorithm for better result in some extra computation time. Computation cost will increase slightly but stability of cluster will increase too. In this WCA computation could have been taken place for avoiding the nodes which has been already participated i.e. already selected cluster member and cluster head will not participate in the cluster formation process but this computation is necessary so that nodes can be added to the cluster. Scenario (a) and (b) could replace this computation for adding in the cluster.

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So there is minimum cost of computation here or stay same as original computation cost.

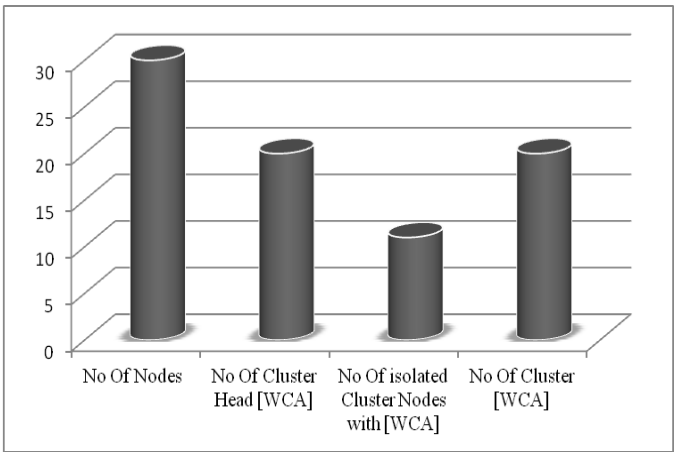

Fig 7:- WCA implementation result

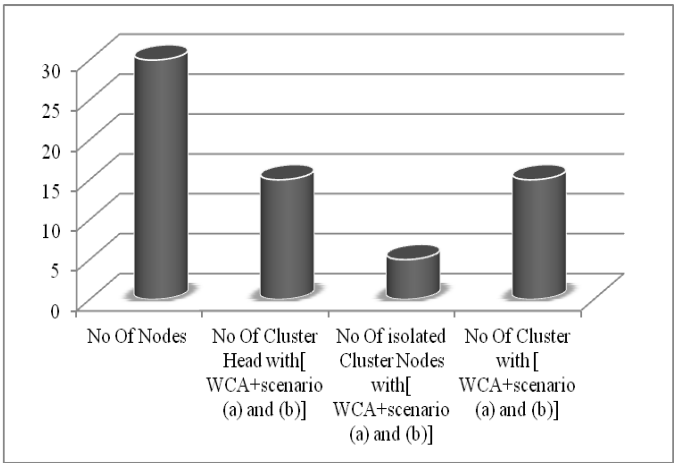

Fig 8:- WCA implementation result after adding scenario(a) and scenario(b)

5. CONCLUSION

Relaxation in weighted clustering algorithm results in better cluster formation. Isolated Cluster head nodes become the cluster member for next selected cluster head due to minimum weight. Isolated node cluster head results due to minimum weight, coming prior in election of cluster head due to minimum weight selection as cluster head, also don't cover any nodes in its range. Since isolated node don't deserve to be cluster head as it is not serving any nodes so it is better to become a cluster member for the next minimum weighted node. For saving the energy further relaxation required for member nodes or ordinary nodes in cluster formation process. Member nodes must join the cluster from which its distance is less from the cluster head. If cluster head covers the other cluster member in the range and it satisfy minimum weight as well as minimum threshold criteria, it must include in its cluster. Practically it is proven fact that as distance from node increases transmission power is required more which results in more energy depletion. So if member nodes are located far from the cluster head it requires more energy to communicate and hence consume more power. So it can be observed by relaxing some of the criteria better cluster formation, energy efficient clustering can be achieved. These methods can be applied in all related weight based clustering to achieve more efficient clustering.

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