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Stable and Flexible Weight based Clustering Algorithm in Mobile Ad hoc Networks

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***Abstract*— Ad hoc networks are wireless, infrastructure less, multi-hop, dynamic network established by a collection of mobile nodes which provides significant features to the modern communication technologies and services. In ad-hoc networks, clustering is an important and familiar technique to divide the large network into several sub networks. According to the dynamic topology the clustering is considers as complicated process in ad hoc networks. In this paper, we have concentrated to design a new weight based clustering algorithm to improve the performance in this wireless technology. Simulation experiments are conducted to evaluate the performance of our algorithm in the transmission range, number of nodes and maximum displacement. Results are shown that our algorithm performs better than existing g algorithms.**

***Keywords*—Ad hoc networks, Clustering, Clustering Algorithms, NS 2**

I. Introduction

Mobile Ad hoc network is also called ad hoc network and mesh network which behaves as self-organizing multi-hop system of wireless nodes which can communicate with each other without any pre-existing infrastructure. With the above ethics this networks are particularly important and useful in battlefields, Military/police exercise, Mine site operations and disaster relief operations, emergency search -and- rescue and so on [1]. 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.

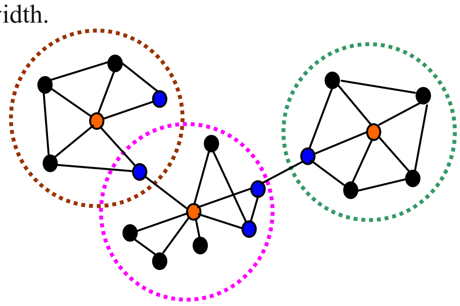

Fig.1 Example of Clustered Network

In this technique, a large network can be divided into several sub-networks with only a few cluster heads maintains the local information [3]. 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. In our self-organized clustering scheme the cluster head only serves the purpose of providing a unique Integer Identification Number (ID) for the cluster, limiting the cluster boundaries. Cluster Gateway (CG) is a non cluster-head node which is used to convey the routing information from one cluster to another. Cluster Member (CM) is a node that is neither a cluster head nor a cluster gateway [9]. The aim of the clustering algorithm is to elect some appropriate node as cluster heads and other member nodes are dominated by the CH. The CH nodes are maintaining the cluster information which contains necessary information of clustering algorithm. After collecting the cluster information the node can exchange the cluster information with its neighbors which is used to construct the path in the certain communication area. In cluster based routing protocol the route messages are graceful by the following method: Source → Cluster Head → Gateway → Cluster Head → Gateway → ··· → Destination [1].

The reminder of this paper has four sections. Section II explains some related clustering algorithms. Section III describes the proposed algorithm. Section IV deals with simulation environment and comparative results with the prior clustering algorithms and the conclusion described in Section V.

II. 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 networks 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. This section contains some graph based clustering approaches i.e. Highest Degree Algorithm, Lowest ID Heuristic, Node-Weight Heuristic, Weight Based Clustering algorithm. The references [3][4][7][10] explains about this deterministic clustering approaches.

The Highest Degree (HD) Algorithm *is* also known as connectivity-based clustering algorithm, was originally proposed by Gerla and Parekh, which performs based on the degree of nodes assumed to be the number of neighbors of a given node. In this algorithm every nodes are broadcast their Identifier (ID) in the same network [3] [7]. According to the number of received IDs every node computes its degree and the one having the maximum degree becomes cluster-head (CH). Major drawbacks of this algorithm include the situation where the degree of a node changes very frequently, and thus the CHs are not likely to play their role as cluster-heads for very long. Moreover, while the numbers of ordinary nodes are increased in a cluster, the throughput drops and system performance degrades. All these drawbacks occur because this approach does not have any restrictions on the upper bound of the number of nodes in a cluster.

The Lowest-Identifier (LID) is also known as identifier-based clustering algorithm, was originally proposed by Baker and Ephremides. In the lowest- ID algorithm every node in the network has designated with unique ID number [4]. All nodes periodically broadcast their ID to those direct neighbors. Each node compares the IDs of its neighbors with its own ID. A node decides to become a CH if it has the lowest ID among its neighbor IDs. However, the CH can delegate its duties to the next node with the minimum ID in its cluster. This heuristic, gives better performance than the Highest-Degree heuristic in terms of the throughput. It has some significant drawbacks like nodes with smaller ids which lead to the battery drainage of certain nodes and also it does not attempt to balance the load uniformly across all the nodes.

The Node-Weight Heuristic [7],[10] approach has two algorithms namely distributed clustering algorithm (DCA) and distributed mobility adaptive clustering algorithm (DMAC), proposed by Basagni et al. In this approach, each node is assigned weights (a real number ≥ 0) based on that a node may be a CH or CM. A node is chosen to be a cluster-head if its weight is higher than any of its neighbor's weight otherwise; it joins a neighboring of CH. The DCA makes an assumption that the network topology does not change during the execution of the algorithm. To verify the performance of the system, the nodes were assigned weights which varied linearly with their speeds but with negative slope. Results proved that the number of updates required is smaller than the Highest-Degree and Lowest-ID heuristics. Since node weights were varied in each simulation cycle, computing the cluster-heads becomes very expensive and there are no optimizations on the system parameters such as throughput and power control.

The Weighted Clustering Algorithm (WCA)[2],[6] 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 (D_v), summation of distances (P_v), mobility (M_v) and cumulative time (T_v). 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

$$W_v = W_1D_v + W_2P_v + W_3M_v + W_4T_v$$

A CH algorithm finishes once all the nodes become either a 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. No two cluster heads can be immediate neighbors.

III. Proposed Work

In this section, we proposed a weight-based clustering algorithm to manage the nodes and maintaining the local topology in an inter-network [6]. First, nodes are exchanging NEIG_MSG with its neighbors to update the cluster information. Then, each node 'p' executes the clustering algorithm to check whether it is suitable to be a cluster head or not. In our clustering algorithm, the maximum hop distance from the cluster head to its farthest cluster member is two hops, and we ensure that each non cluster head node is managed by only one cluster head which is one of its neighbors within two hops [1]. So, we can define the weight function w(p) to calculate the weight of each node. For each node p, the weight function w(p) is defined as:

$$w(p) = 3\,t(p) + 2\,s(p) + r(p)$$

t (p) and s(p) are the number of multicast member neighbors one hop and two hop respectively and r (p) is the number multicast member and cluster member neighbors are being within two hops.

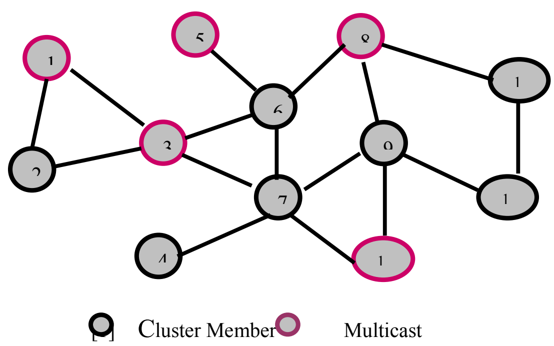

Fig 2. An Example of Weight calculation

For example, in Fig.2 the weight function of each node can be calculated as follows:

$$w(1) = 3 \times 1 + 2 \times 0 + 4 = 7$$
$$w(2) = 3 \times 2 + 2 \times 0 + 4 = 10$$
……..
……..
$$w(11) = 3 \times 1 + 2 \times 0 + 4 = 7$$
$$w(12) = 3 \times 0 + 2 \times 2 + 5 = 9$$

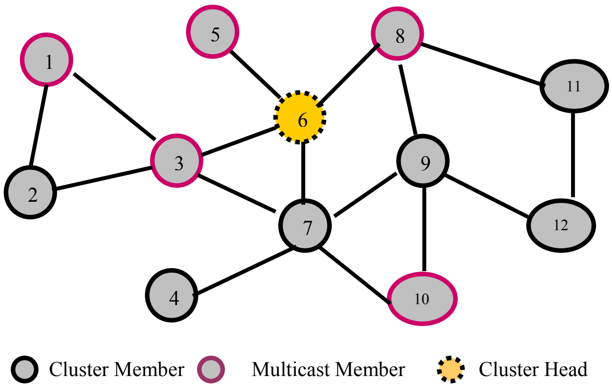

Fig 3. An Example of Cluster Head Election

After the weight calculation, each node compares the weight with its neighbors within two hops for cluster head election. The node which has the largest weight will declare itself as a cluster head. In the above example network the node 6 has the largest weight and it becomes the cluster head and other nodes are behaving as cluster member node after the following message conformation. The CH node sends the HEAD_INTIMATION _MSG to the neighbor's nodes. Once a normal node with receives a HEAD_INTIMATION _MSG, it sends an MEMBER_ACK_MSG to the corresponding cluster head for joining the cluster. While the clustering procedure of each node is completed, the network is well-clustered and ready to construct the route and set forwarding clusters [8]. In addition that, every nodes are maintaining the cluster information and the cluster member information is also maintained by cluster heads. Since the neighbor information within two hops is only required for clustering, the overhead incurred by exchanging messages with neighbors within two hops is diminished after clustering. Generally, an efficient clustering algorithm should avoid creating too many small clusters, since incomplete clusters may lead to high maintenance overhead and reduce the performance of the cluster-based routing. If we apply this proposed clustering algorithm for multicasting this is easy to group neighboring multicast members into a same cluster so that the number of clusters with multicast members can be as small as possible [5]. As well as we can reduce the total number of clusters as well as the number of incomplete clusters. Thus, the node has a larger weight is preferred as being a cluster head since it could manage more multicast members as well as normal nodes. Additionally, the proposed clustering algorithm also provides for multicast sources to share the existing routes, thus further reducing control overhead and preserving efficiency.

Overall, our clustering algorithm possesses the following advantages:(1) Neighboring multicast members have high possibilities to be grouped into a same cluster, which provides a better capability for sharing routes among multicast members, and thus conduces to higher multicast efficiency as well as lower maintenance overhead. (2) The number of clusters in the network will be reduced by using our 2-hop weight-based clustering algorithm. (3) This improves the stability of cluster and incurs less maintenance overhead comparing with existing clustering algorithms [1].

IV. 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 NS2 [11]. 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 [12].

B. Simulation Study

In our Simulation experiments N was varied between 50 and 300 and the R was varied between 0 and 200. At every time unit, the nodes are moved randomly according to the random way point model in all possible directions in 250 * 250 meters square space. Number of simulation is 10; duration is 200 sec and 5 secs for the pause.

Table I
Simulation Parameters

Parameter	Meaning	Value
N	Number of nodes	50 – 300
X * Y	Simulation Area	250 * 250 m
R	Transmission Range	0-200 m
MD	Maximum Displacement	0-10 m
Duration	Simulation time	200 sec
PT	Pause Time	5 sec
Mobility Model	Random way point	--
Simulation	Number of simulation	10

C. Simulation Results and Discussion

This section has been focused to prove the performance of our ProWBCA with the deterministic LID,HD and WCA in terms of transmission ranges, number of nodes and maximum displacement . The Fig.4 drawn for the simulation result of transmission range and average number of clusters which proves the proposed WBCA approach is giving minimum number of clusters while increasing the transmission range than deterministic approaches. The LID and HD algorithms are having minimum differences in average number of clusters. For this Fig.4 comparison we taken N = 300 and MD = 10.

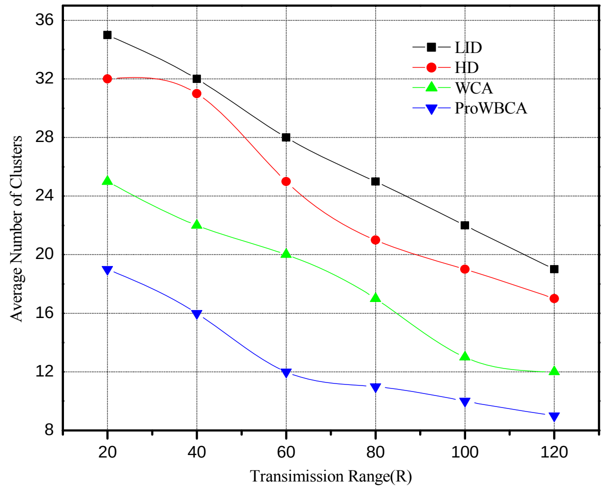

Fig.4 Relation between Transmission Range and Average number of clusters
N = 300 and MD = 10

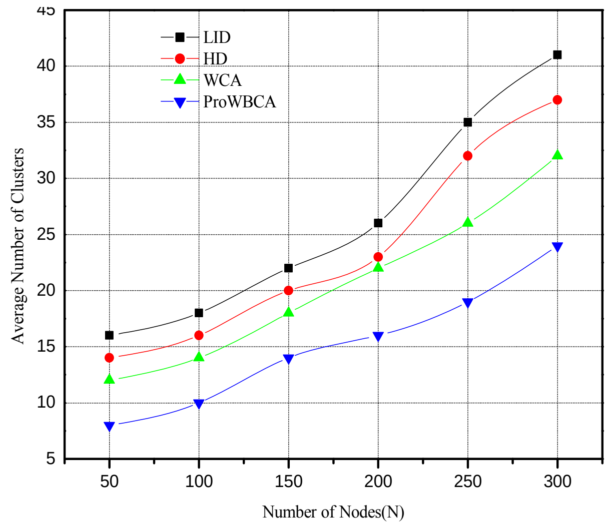

Fig.5 Relation between Number of Nodes and Average number of clusters
R = 100 and MD = 10

The Fig 5.Shows the result of LID,HD,WCA and ProWBCA clustering algorithms average number of clusters while increasing the number of nodes which explains the proposed approach formed minimum number of clusters than our existing approaches. For this relation R and MD are taken as 100 and 10 respectively.

The Fig 6. Shows the comparison of deterministic and ProWBCA approaches between average number of clusters in various displacements. In this comparison the proposed approach provides minimum number of clusters than existing LID, HD and WCA. Moreover, which proves the deterministic approaches are having only minimum differences among them. For this comparative result number of nodes and transmission range is taken as 300 and 80 respectively.

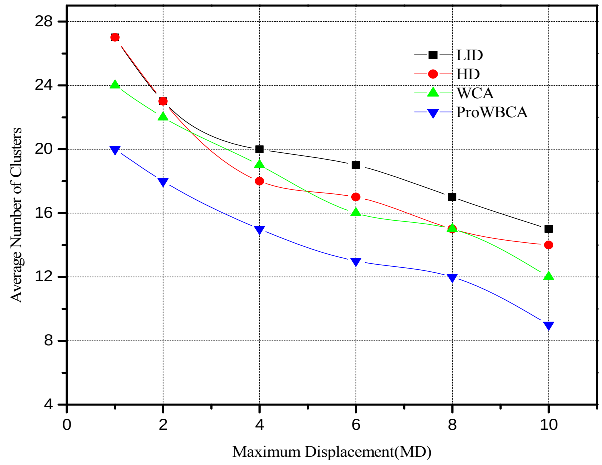

Fig.6 Relation between Maximum displacement and Average number of clusters
N = 300 and R = 80

V. Conclusion

This paper has presented a flexible weight based clustering algorithm in mobile ad hoc networks. Comparing with conventional 1-hop clustering algorithms, this proposed 2-hop clustering algorithm is more stable and flexible against topology changes but which requires more information during the cluster construction. For this clustering algorithm various parameters and different coefficients are taken for the weight function hence it may be suited for different applications and network environments. The performance of this proposed clustering algorithm demonstrated that it outperforms than the existing LID,HD and WCA to make the number of clusters while increase the number of nodes, transmission range and maximum displacement.

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