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A Weighted Cluster Based Routing Protocol for MANET

Aswathy P Sreevatsan*, Diya Thomas
Department of Computer Science,
RSET, Kerala, India

Abstract— Grouping of nodes into different groups or clusters is known as clustering. Manet is a type of ad hoc network in which the nodes change locations frequently. Clustering of a MANET thus helps to aggregate network information and makes the task of routing easier. Each cluster will contain a node known as the Cluster Head(CH) which takes care of routing and resource allocation in the network. Nodes register themselves with a cluster head to join that particular cluster. A node that belongs to more than one cluster is a gateway node. Since the nodes are mobile, the clusters tend to be unstable . Thus reclustering of the network cannot be avoided. Many clustering techniques have been proposed over the years, but weighted clustering is more efficient because it takes into account more than one network parameter to cluster the network. After clustering, a path is explored between two nodes through the clusters which will contain only the CHs and gateway nodes. This leads to long lived paths. This paper proposes certain modifications on the weighted clustering algorithm which includes malicious node detection before clustering, a new reclustering scheme and the use of fuzzy logic to choose the best path through the clusters.

Keywords— Clustering, Cluster Head Selection, Fuzzy logic, MANETs, Weighted Clustering.

I. INTRODUCTION

MANET is a network in which nodes are mobile. Thus clustering helps to manage the network in a better way minimizing the network information that is needed when carrying out the network activities(eg.routing). Clustering is the technique that aggregates nodes into groups to make network management easier[1]. Each cluster has a cluster head that monitors the cluster.Nodes play completely different roles in clustering techniques and there are 3 kinds of nodes

a. Ordinary nodes
b. Cluster head
c. Cluster gateways nodes

Cluster head nodes: Cluster head is a support or backbone to sustain all essential control functions of the cluster. The function of cluster head is internal node communication and to forward intercluster messages.
Cluster gateway nodes: A node is called a gateway if it lies within the transmission range of two or more cluster heads.Gateway nodes are generally used for routing between clusters.
Ordinary nodes (cluster member):They are members of the cluster and does not have any specific function.
The figure 1 below illustrates the different types of nodes and cluster structure.

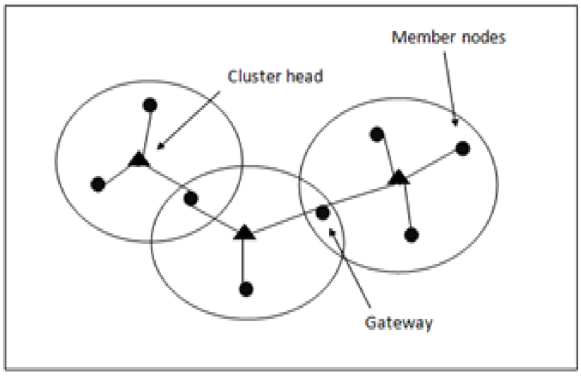


Figure 1: Cluster Structure

II. LITERATURE SURVEY

The clusters may change dynamically due to the movement of nodes. A number of methods have been proposed to choose cluster heads in ad hoc networks. They include (i) Highest-Degree heuristic,(ii) Lowest-ID heuristic, and (iii) Node-Weight heuristic. The Highest-Degree[2], also known as connectivity-based clustering is a clustering algorithm in which the degree of a node is computed based on its distance from others. Cluster head will be the node with maximum number of neighbours and any tie is broken by the unique node ids. The Lowest-ID[2], also known as identifier-based clustering, is a heuristic that assigns a unique ID to each node and chooses the node with the minimum ID as a cluster head. Thus, the IDs of cluster head will be lesser than that of the neighbours of the cluster head. In Node Weight Heuristic[3], each node is assigned weights based on its suitability of being a cluster head depending upon a parameter (eg. mobility). A node is chosen to be a cluster head if its weight is higher than any of its neighbours weight;otherwise, it joins a neighbouring cluster head. None of the above three heuristics leads to an optimal election of cluster heads since each deals with only a subset of parameters which can possibly impose constraints on the system. Thus weighted clustering algorithm (WCA) was introduced to compute node weights taking different factors into consideration.

WCA algorithm has improved the route discovery in MANETS.The WCA algorithm [3] takes into account a multiple factors such as battery power ,mobility, distance to its neighbors,degree of the node to compute the weight and select the cluster heads. The basic WCA algorithm do not specify how to normalize the parameters before applying to the formula. CBDM[4] specifies a new method of measuring the parameters and considers the residual battery power in the nodes. It also specifies how to normalize the parameters. The enhanced algorithm based on WCA[5] deals with sending of a number of messages between the nodes to elect and maintain the clusteheads. The disadvantage of this technique is that there is no guarantee that the messages reach the node properly. The AWCBRP algorithm [6] also uses beacon signals which consume a lot of energy. The PAIWCA algorithm [7] optimizes the WCA algorithm by considering the probability of a newly coming node to assign it to a cluster, thus reducing the computation. The mobility prediction algorithm [8] also helps to reduce the computation by predicting the position of nodes. This leads to reduced beaconing thus conserving energy. The innovative cluster stability based algorithm [9] also describes how to assign an incoming node to a cluster taking load balancing factor into consideration and concentrates more on the cluster stability. The IWCA algorithm [10] on the other hands helps to filter out malicious nodes before clustering. We propose here certain modifications on the WCA algorithm and propose a method to select the best route among the nodes using fuzzy logic [11].

III. WCA

The design approach to implement an efficient WCA algorithm should start by implementing the basic WCA functionalities. Thus the implementation starts by implementing the basic WCA[3] algorithm. WCA take into account nodes degree, distance to the neighbbors, mobility and battery power to select a cluster head. WCA combines each of these four parameters with certain weighing factors chosen according to the system needs. The flexibility of changing the weight factors helps to apply the algorithm to various networks. The output of clusterhead election procedure is a set of cluster heads called the dominant set. According to the notation, the number of nodes that a clusterhead can handle ideally is δ. This is to ensure that clusterheads are not over-loaded and the efficiency of the system is maintained at the expected level.

The procedure consists of eight steps as described below:

Step 1. Find the neighbors of each node v (i.e., nodes within its transmission range) which defines its degree, d_v as

$$d_v = |N(v)| = \sum_{v' \in V, v' \neq v} dist(v', v) < t_{xrange} \qquad (1)$$

where V is the node set and t_{xrange} is the transmission range of the node.

Step 2. Compute the degree-difference, $\Delta v = |d_v - \delta|$, for every node v.

Step 3. For every node, compute the sum of the distances, D_v, to all its neighbors as

$$D_v = \sum_{v' \in N(v)} dist(v', v) \qquad (2)$$

Step 4. Compute the running average of the speed for every node till current time T. This gives a measure of mobility and is denoted by M_v.

Step 5. In basic WCA the algorithm the cumulative time, Pv, during which a node v acts as a clusterhead, Pv, implies how much battery power has been consumed, which is assumed more for a clusterhead than an ordinary node. In our method the residual battery power or energy of the node is taken for energy calculation which can be denoted by variable Ev ..

Step 6. Calculate the combined weight W_v for each node v, Where

$$W_v = w1\Delta v + w2D_v + w3M_v + w4E_v \qquad (3)$$

where w1,w2,w3 and w4 are the weighing factors for the corresponding system parameters.

Step 7. Since the clusterhead must have low value of Δv, low mobility, lesser distance to its neighbors and lesser P_v we choose node with smallest weight value as the cluster head (CH). All the neighbors of the chosen clusterhead are no longer allowed to participate in the election procedure.

Step 8. Repeat steps 2 to 7 for the remaining nodes not yet selected as a cluster head or assigned to a cluster.

Thus the implemented system emphasises on starting with different energy levels for each node initially. For each re-clustering, weight is calculated again and the energy is decreased by a fixed value. The weight function is modified to include the residual energy of the nodes other than the time for which the node acts as clusterhead. This gives a more accurate measure of the energy.

IV. IMPLEMENTATION

It is assumed that the network is static and that the nodes are not moving till clustering is done. The algorithm starts by broadcasting through the network to find the malicious nodes to eliminate from clustering process. Then after calculating the weights , the clustering process takes place . Then the nodes start moving which leads to re-affiliation and re-clustering based on the stability factor variation.

In our simulation experiments, number of nodes was varied between 10 and 30, and the transmission range was varied between 30 and 70. The nodes are moved with a maximum displacement of 30 along each of the coordinates. Due to the importance of keeping the node degree as close to the ideal as possible, the weight w1 associated with Δv was chosen high. The next higher weight w2 was given to Dv, which is the sum of distances. Mobility and battery power were given low weights. The values used for simulation were w1 = 0.7;w2 =0.2;w3 = 0.05 and w4 = 0.05.

To quantitatively measure how well balanced the clusterheads are, load balancing factor (LBF)[3] is calculated. As the load of a clusterhead can be represented by the cardinality of its cluster size, the variance of the cardinalities will signify the load distribution. The LBF is the inverse of the variance of the cardinality of the clusters. Thus,

$$LBF = n_c / \sum (x_i - \mu)^2 \qquad (4)$$

where n_c is the number of clusterheads

x_i is the cardinality of cluster i

$\mu = (N - n_c)/n_c$ is the average number of neighbors of a clusterhead

N being the total number of nodes in the system .

In our experiments, for a perfectly balanced cluster the LBF value obtained is infinity.

The Fig 2.(a) shows the variation of the average number of clusterheads with respect to the transmission range. The results are shown for varying N. We observe that the average number of clusterheads decreases with the increase in the transmission range. This is due to the fact that a clusterhead with a large transmission range will cover a larger area.The Fig 3.(a) and Fig 3.(b) shows the variation of load balancing factor with cluster densities in a network of four clusters and five clusters respectively.

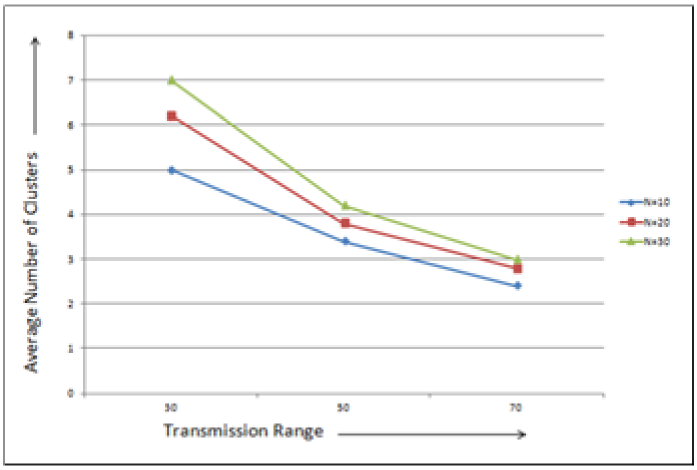
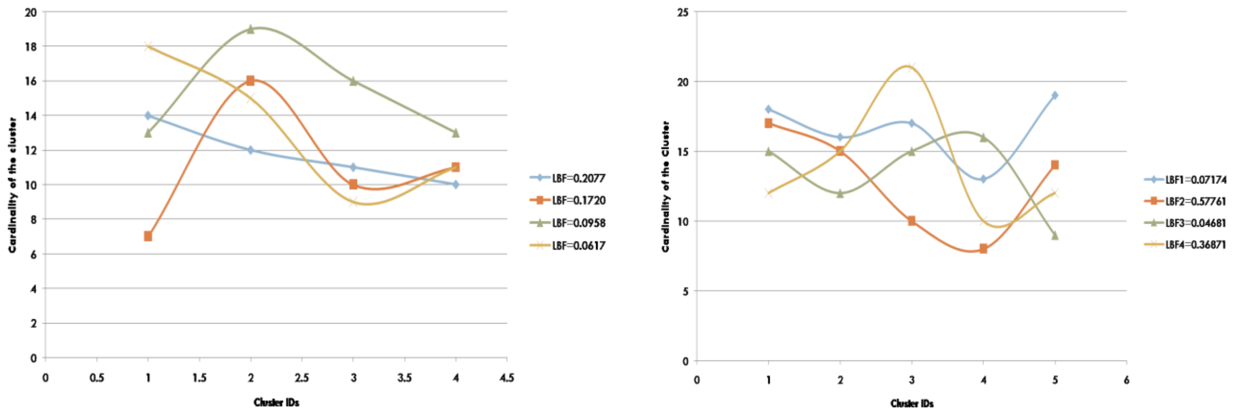


Fig 2.(a) Average number of clusters vs. Transmission range (for different node densities)



(a) (b)

Fig 3. (a) Variation of LBF according to different cluster cardinality in 4 clusters, (b) Variation of LBF according to different cluster cardinality in 5 clusters

V. FUTURE WORK

The WCA algorithm can be extended to include three new phases :

- Malicious Node Detection Phase
- Stability factor based reclustering phase
- Fuzzy logic based route selection phase

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A. Malicious Node Detection

A network may contain malicious nodes that may harm the regular functioning of the network. The presence of such nodes can lead to depletion of network resources and malfunctioning in the network. Thus early detection and removal of such nodes should be done. The detection of malicious nodes that simply drop packets can be done by finding the packet drop ratio of each node and then excluding them from the clustering process.

B. Stability factor based reclustering

The reclustering in WCA happens when a node moves out of the range of all clusters. The movement and reaffiliation of nodes may lead to overloading of some clusters in the network. Thus a new term known as cluster stability factor is introduced which depends on factors such as

- Cluster head velocity (chv)
- Number of nodes in the cluster with high velocity (avn)
- Number of nodes in the cluster with low battery power (ab)
- Distance between the cluster head and the farthest node (dchf)
- The remaining battery power of the cluster head. (abn)
- Number of nodes in the cluster (n)

The stability factor of each cluster is found out and the average stability factor of the network is calculated. The average stability factor can be compared with that of a refrence network to check if reclustering is needed.

C. Fuzzy logic based route selection phase

The route between any two nodes is explored between the clusters they belong to. The route between nodes consist of the gateway nodes and the cluster heads in the path. But suppose there are more than one path explored between two nodes,the ideal path will be the one with nodes having high energy and low velocity. This eliminates paths that contain routes that may contain nodes that tend to die soon . Thus given multiple paths between two nodes through the clusters, the best path can be chosen using fuzzy logic .Fuzzy system consists of three parts fuzzification, inference engine and defuzzification.

Fuzzification: In this stage, the two input variables, residual battery power(energy) and velocity(mobility) of the nodes in each path, are converted into linguistic values by using membership functions to determine the membership degree. The linguistic values can be low,medium and high. The figures 4.a and 4.b shows the membership functions for values of the input parameter.

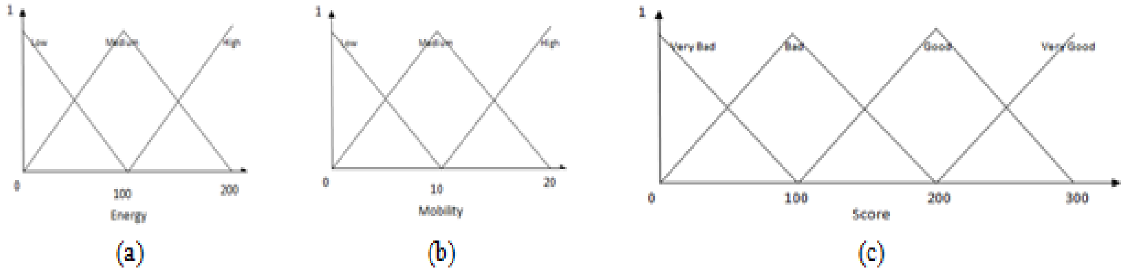

Fig. 4. Membership functions of (a) Energy (b) Mobility (c) Output Score

Inference engine: The rule base consists of series of regulations in IF-THEN form, here we have 9 different rules. Table 1 shows some samples of used rules in this research. Input fuzzy parameters are applied to existing rules in the rule base and the rule adaptable to input parameters are activated . Depending upon the rules triggered the output values (Very Bad,Bad,Good,Very Good) of the nodes are computed.

Table 1 . Sample Rules

Energy	**Mobility**	**Output**
High	Low	Very Good
Low	High	Very Bad
Medium	Low	Good
Medium	Medium	bad

Defuzzification: The inputs of this phase are the output linguistic values of the nodes and the outputs are non-fuzzy values. The score is computed according to figure 4(c).

Finally, the scores of all the nodes in all the available paths will be obtained. If the majority of the nodes have good scores then the path will have higher priority. The goodness of a score is determined by checking if the score is above the average of the scores of all nodes in the available paths. The path with highest priority is chosen for routing. If the selected path contains a node with a bad score ,then the next highest priority path is selected .Thus routing happens only through the best path.

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VI. CONCLUSION

A mobile ad hoc network (MANET) is a continuously self-configuring, infrastructure-less network of mobile devices connected without wires. Each device in a MANET is free to move independently in any direction, and will therefore change its links to other devices frequently. MANETS have highly dynamic, autonomous topology. This makes routing in MANET a tedious process. Clustering is a process that helps in efficient handling of MANETs. WCA algorithm takes into account a multiple factors for clustering. WCA along with fuzzy logic can be used to find best routes between any two nodes.The network can be cleansed by running a malicious node detection algorithm prior to the clustering process. A new factor known as stability factor is introduced which calculates the stability of the clusters to check if reclustering is needed or not.

REFERENCES

[1] 1.Jane Y. Yu And Peter H. J. Chong, "A Survey Of Clustering Schemes For Mobile Ad-Hoc Networks", IEEE Communications Surveys and Tutorials, First Quarter 2005.

[2] 2. Ratish Agarwal, Dr. Mahesh Motwani, Survey of clustering algorithms for MANET, International Journal on Computer Science and Engineering Vol.1(2), 2009, 98-104

[3] 3. Mainak Chatterjee, Sajal K. Das, and Damla Turgut, WCA: AWeighted Clustering Algorithm for Mobile Ad Hoc Networks, Cluster Computing, Vol. 5, No. 2, pp. 193-204, April 2002.

[4] 4. AbdelRahman Hussein, Sufian Yousef, Samir Al-Khayatt, Omar S. Arabeyyat, An E_cient Weighted Distributed Clustering Algorithm for Mobile Ad hoc Networks , 978-1-4244-7042-6/10/2010 IEEE

[5] 5. Wojciech Bednarczyk, Piotr Gajewski1, An Enhanced Algorithm for MANET Clustering Based on Weighted Parameters, Universal Journal of Communications and Network 1(3): 88-94, 2013

[6] 6. S.Karunakaran And Dr.P.Thangaraj , An Adaptive Weighted Cluster Based Routing (AWCBRP) Protocol for Mobile Ad-hoc Networks ISSN:1109-2742 Issue 4, Volume 7, April 2008

[7] 7. S.Rohini, K.Indumathi, Consistent Cluster Maintenance Using Probability Based Adaptive Invoked Weighted Clustering Algorithm in MANETs , Proceedings of the National Conference on Innovations in Emerging Technology-2011C.

[8] 8. S.Muthuramalingam, R.RajaRam, Kothai Pethaperumal and V.Karthiga Devi , A Dynamic Clustering Algorithm for MANETs by modifying Weighted Clustering Algorithm with Mobility Prediction , International Journal of Computer and Electrical Engineering, Vol. 2, No. 4, August,2010

[9] 9. Mohammad Shayesteh and Nima Karimi, An Innovative Clustering Algorithm for MANETs Based on Cluster Stability, International Journal of Modeling and Optimization, Vol. 2, No. 3, June 2012

[10] 10. Likun Zou, Qishan Zhang, Jianwei Liu, An Improved Weight-Based Clustering Algorithm in MANETs , 978-1-4244-2108-4/08 2008 IEEE

[11] 11. Ehsan Amiri, Ali Harounabadi and Seyed Javad Mirabedini, Nodes clustering using Fuzzy logic to optimize energy consumption in Mobile Ad hoc Networks", Management Science Letters 2 (2012) 30313040