Volume 4, Issue 9, September 2014 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Clustering Algorithm in Manets for Stable Cluster Recent Trends Survey

Gajendra Singh
HOD CS M.Tech SSSIST
Sehore, India

Deepa Upadhyay*
M.Tech Secholar SSSIST
Sehore, India

Kapil Vyas
Lecturer BMCT
Indore, India

Abstract— A mobile ad hoc network (MANET) is a self configuring network of mobile devices connected by wireless links. In order to achieve stable clusters, the cluster-heads maintaining the cluster should be stable with minimum overhead of cluster re-elections. This work proposes selecting stable cluster heads using a modified Weighted Clustering Algorithm and combining it with Link Expiration Time calculation. The mobile ad hoc network consists of nodes that move freely and communicate with each other. One way to support efficient communication between nodes is to partition ad hoc networks into clusters. Many clustering schemes have been proposed to form clusters. The WCA has improved performance compared with other previous clustering algorithms. However, the high mobility of nodes will lead to high frequency of re-affiliation which will increase the network overhead. To solve this problem, we propose a time-based WCA which can enhance the stability of cluster formation followed by stable cluster head selection.

Keywords— MANET, Ad-hoc networks, Clustering, Cluster Head (Ch), Cluster-Head Probability, Dominant Set, Stable Clustering, Time to Link.

I. INTRODUCTION

In recent years, wireless mobile terminals such as smart phones spread widely and mobile ad-hoc networks (MANETs) attract more and more attention. It is expected that MANETs' applications promise scalability and self-adaptability because the networks change frequently as mobile terminals join in, move around, and leave from the network. Hence, many researchers work on adaptive and distributed management for MANETs. Another desired property for applications in MANETs is stability, i.e., stable application services even in the presence of topology changes.

Mobile ad hoc networks (MANETs) consist of mobile devices that form the wireless networks without any fixed infrastructure or centralized administration .In Ad hoc networks, clustering algorithm and select suitable nodes in clusters as cluster heads are so important. This is just because, cluster heads acts as local coordinators and handle various network functions. The clusters are able to store minimum topology information; each CH acts as a temporary base station within its zone or cluster and communicates with other Chs. A clustering scheme should be adaptive to changes with minimum clustering management overhead incurred by changes in the network topology. Figure 1 gives an overview of clustering architecture in MANET its show clearly cluster head as dark circles and gateway or member node in light circles.

Self-stabilization [1] is well known as one of the design approaches for distributed algorithms. After topology changes and/or faults, a self-stabilizing system recovers automatically without any human intervention. This autonomous adaptability is suitable for MANETs and many researchers work on this topic [2]. However, self-stabilizing systems are not stable because they are inherently sensitive to changes (i.e., topology changes and faults) to achieve adaptability. A cluster structure enables hierarchical network management and it is used as a fundamental technique for scalable management of a large-scale network. A cluster structure divides a network into groups called clusters, each of which consists of one cluster head and some ordinary nodes. In each cluster, the cluster head controls the communications in intra cluster and inter-clusters. In MANETs, as some nodes join, move, and leave, the cluster structure should be updated, while if a cluster structure changes frequently and drastically (e.g., a node alternates its role from an ordinary node to a cluster head or joins in or leaves from a cluster), communication overhead may increase. To reduce unnecessary communication and to keep providing stable service for external application using the cluster structure, stable cluster structure is necessary.

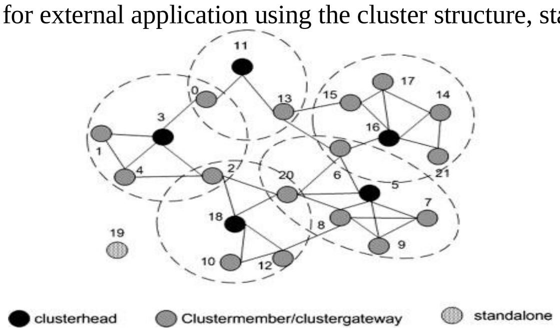

Fig. 1 MANET Clustering Architecture

The previous research on mobile ad-hoc network has heavily stressed the use of clustering algorithm because clustering simplifies routing and can improve the performance of flexibility and scalability, improved bandwidth utilization, and reduce delays for route strategies. In a clustering structure, the mobile nodes in a network are divided into several virtual zones (clusters). The process of clustering is never completed without a proper maintenance Scheme. The objective of cluster maintenance is to preserve as much as of the existing clustering structure as possible. The node movement in the network results in frequent link failure or link establishment between the nodes. This demands cluster member updating to take place from time to time.

Moreover, the changing topology and node lifetime / capability (with respect to its available battery power) eliminate the possibility of permanent cluster heads. Thus new cluster heads are required to be elected with the changing scenario. Hence, a well designed clustering algorithm needs to follow a least maintenance overhead phase.

Scalability is of particular interest to ad hoc network designers and users and is an issue with critical influence on capability and capacity. Where topologies include large numbers of nodes, routing packets will demand a large percentage of the limited wireless bandwidth and this is exaggerated and exacerbated by the mobility feature often resulting in a high frequency of failure regarding wireless links. To overcome such barriers to success and address the issues of scalability and maintenance of MANETs it is essential, "to build hierarchies among the nodes, such that the network topology can be abstracted. This process is commonly referred to as clustering and the substructures that are collapsed in higher levels are called clusters" [3]. Increasing network capacity and reducing the routing overhead through clustering brings more efficiency and effectiveness to scalability in relation to node numbers and the necessity for high mobility. The manager node- CH (Clusterhead) – in clustering has responsibility for many functions such as cluster maintenance, routing table updates, and the discovery of new routes. However, the recurrent changes faced by the cluster head can lead to losing stored routing information, route changes between node pairs and ultimately impacts on the overall performance of the routing protocol because of cluster structure instability [4]. For these reasons this paper will focus on how to elect a clusterhead to keep the stability of network topology.

II. RELATED WORK

The main objective of clustering in mobile ad-hoc network environments is how can an optimal cluster head be elected and how can the optimal number of clusters be achieved through division without degrading the whole network's performance. In paper [5] we propose new weighted distributed clustering algorithm, called CBMD. It takes into consideration the parameters: connectivity (C), residual battery power (B), average mobility (M), and distance (D) of the nodes to choose locally optimal cluster heads. The goals of this algorithm are maintaining stable clustering structure with a lowest number of clusters formed, to minimize the overhead for the clustering formation and maintenance and to maximize the lifespan of mobile nodes in the system.

Johnen et al. proposed a self-stabilizing clustering algorithm which treats a MANET as a vertex-weighted graph. The algorithm has autonomous adaptability against topology changes and weight changes, while it does not consider the stability of clusters. In paper [6], we present a weight assignment method that reflects the mobility of each node to its weight so that the stability of clusters is improved. The proposed method makes nodes that move together maintain a cluster by considering mobility groups of nodes.

All of these clustering algorithms are based on the assumption that the information of each member node is known to every cluster-head. However, if a mobile station enters a collision free zone and it will become a kind of interference to the MANET system; the cluster-head could not notice this interference. This paper [7] analyses the mobile hidden station problem for WCA in MANET. Computer simulates the network average throughput, load balance factor (LBF) and fairness between traditional WCA with or without mobile hidden station.

In paper [8], authors establish a cluster update interval model and use this model to determine a reliable update interval for the cluster structures in MANETs. This update interval is affected by two main factors: nodes' relative mobility and transmission range. We establish a cluster update interval model which uses the expected link lifetime with respect to the cluster-head (CH) as the update interval. The proposed model takes all of the above mentioned factors into consideration and no weights combination is needed.

A mobile ad hoc network (MANET) is a self configuring network of mobile devices connected by wireless links. In order to achieve stable clusters, the cluster-heads maintaining the cluster should be stable with minimum overhead of cluster re-elections. In paper [9] propose a Probability Based Adaptive Invoked Weighted Clustering Algorithm (PAIWCA) which can enhance the stability of the clusters by taking battery power of the nodes into considerations for the clustering formation and electing stable cluster-heads using cluster head probability of a node.

Clustering can help aggregate the topology information and reduce the size of routing tables in a mobile ad hoc network (MANET). To achieve fairness and even energy consumption, each cluster head should ideally support the same number of cluster members. Moreover, one of the most important characteristics in MANETs is the topology dynamics, that is, the network topology changes over time due to energy conservation or node mobility. Therefore, for a dynamic and complex system like MANET, an effective clustering algorithm should efficiently adapt to each topology change and produce the new load balanced solution quickly. The maintenance of the cluster structure should be as stable as possible to reduce overhead. It requires that the new solution should try to keep most of the good parts in the previous solution. In paper [10], author proposes to use elitism-based immigrant's genetic algorithm (EIGA) to solve the dynamic load balanced clustering problem in MANETs. Each individual represents a feasible clustering structure and its fitness is evaluated based on the load balance metric. Immigrants are introduced to help the population to handle the topology dynamics and produce new and closely related solutions.

In large Mobile Ad Hoc Networks (MANET), forming clusters of nodes has been verified to be a promising approach in high mobility network. The characteristics of MANETs are dynamic topology, bandwidth and link capacity, nodes are energy constrained. Clustering methods allow fast connection and topology management, better routing and also improve network performance parameters like routing delay, bandwidth consumption and throughput. In MANET, topology changes dynamically, so to achieve good performance any clustering algorithm should operate with minimum overhead of cluster maintenance and try to preserve its structure as much as possible when nodes are moving and/or the topology is slowly changing. A large variety of approaches for ad hoc clustering have been developed by researchers which focuses on different performance metrics. This paper presents a survey of different clustering schemes. A comparative analysis of various techniques also have been covered in paper [11].

In hierarchical networks, the efficient choices of cluster-head as well as the cluster update interval is important to keep the established cluster structure stable and improve the communication quality. In paper [12], author establish a cluster update interval model and use this model to determine a reliable update interval for the cluster structures in MANETs. This update interval is affected by two main factors: nodes' relative mobility and transmission range. We establish a cluster update interval model which uses the expected link lifetime with respect to the cluster-head (CH) as the update interval. The proposed model takes all of the above mentioned factors into consideration and no weights combination is needed. Simulation results shows that our proposed model can help to determine a dynamic cluster update interval adapting to various scenarios and achieve better stability in the cluster structure.

In paper [13] author provides a new algorithm to solve mobile hidden station problem in MANET (Mobile Ad Hoc Network). As is known, mobile hidden station problem is very common in MANET and degrades the network throughput severely. MANET realizes the space diversity by choosing a cluster-head (relay node) and allocating its member nodes. Cluster-heads has a good quality among member nodes. When mobile hidden station enter a cluster where its cluster-head is communicating with one of member nodes, collision happens and the data frames that have been transmitted must be given up and seen as invalid. In this condition, the cluster-head has no ability to find out the interference and this causes a great waste of MANET resource. In order to solve mobile hidden station problem in MANET, provide a new algorithm called Improved RTS-CTS algorithm, which improves network performance (throughput and collision rate) compared with the original RTS-CTS algorithm.

Paper [14] presents a new, differential-evolution based method for solving the problem of optimal selection of cluster-heads and cluster-members in mobile ad hoc networks. A novel encoding scheme is used to represent nodes in the network graph, and randomly-generated networks of different sizes are solved. The present method handles problems of much larger sizes than do the best-known methods in the literature. Empirical results show the superiority of this method over state-of-the-art approaches on two counts: quality of the solution and time to find the solution.

III. PROBLEM FORMULATION

The mobility of nodes coupled with the transient nature of wireless media often results in a highly dynamic network topology. Due to mobility some nodes will detach from the current cluster and attach itself to some other cluster. The process of joining a new cluster is known as re-affiliation. If the re-affiliation fails, the whole network will recall the cluster head election routine. One disadvantage of WCA is high re-affiliation frequency. High frequency of re-affiliation will increase the communication overhead. Thus, reducing the amount of re-affiliation is necessary in ad hoc networks. To prevent this we go for mobility prediction schemes. The impact of mobility prediction schemes on the temporal stability of the clusters obtained using a mobility-aware clustering framework. We propose a simple framework for a mobility prediction-based clustering to enhance the cluster stability.

The previous research on mobile ad-hoc network has heavily stressed the use of clustering algorithm because clustering simplifies routing and can improve the performance of flexibility and scalability, improved bandwidth utilization, and reduce delays for route strategies. In a clustering structure, the mobile nodes in a network are divided into several virtual zones (clusters). The process of clustering is never completed without a proper maintenance scheme. The objective of cluster maintenance is to preserve as much as of the existing clustering structure as possible. The node movement in the network results in frequent link failure or link establishment between the nodes. This demands cluster member updating to take place from time to time.

Moreover, the changing topology and node lifetime capability (with respect to its available battery power) eliminate the possibility of permanent cluster heads. Thus new cluster heads are required to be elected with the changing scenario. Hence, a well designed clustering algorithm needs to follow a least maintenance overhead phase.

IV. PROPOSED METHODOLOGY

A. Cluster Formation

In WCA, the goal is to minimize the value of the sum of all cluster-heads weighted cost. Here a node is selected as cluster head when it minimize a function of four criteria such as degree(number of direct link to its neighbors), sum of distance between cluster head and other nodes, mobility of nodes and battery power of the nodes.

When a new node arrives WCA calls the clustering algorithm to determine the weight of the new node for the possibility of being a cluster head. This maximizes overhead in WCA when a new comes. To overcome this drawback of WCA, weight of the node should be known prior to the clustering setup. To achieve this node’s weight is calculated using the parameters independent of the clustering setup. In PAIWCA each node computes its weight value based on the following parameters:

- Mobility of the node: Calculate the average speed for every node until the current time T. This gives the measure of the mobility Mv.
- Power consumed: Determine how much battery power has been consumed at Pv. This is assumed to be more for a cluster-head when compared to an ordinary node
- Transmission Rate: Determine the transmission rate for each node at Tx. This is assumed to be high for a cluster-head.
- Transmission Range: Transmission range for each node (Tr) is calculated independently for each node.
- Cluster head probability of node (Chprob).
- The weight Wv for each node is calculated independent of the neighbors and the clusters, using the parameters
    1. Transmission Range, Tr
    2. Transmission Rate, Tx
    3. mobility of the node, Mv
    4. power consumed, Pv
    5. C
- Calculation of weight: Wv=(a x Tr)+ (b x Tx) + (c x Mv) + (d x Pv) - chprob.
- The Values for the constants in such manner as a+b+c+d=1.
- Once the weights of the nodes are calculated before the clustering setup, the node with minimum weight is chosen to be the cluster-head and its neighbors are no longer allowed to participate in the election procedure.
- All the above steps are repeated for remaining nodes which is not yet elected as a cluster-head or assigned to a cluster.

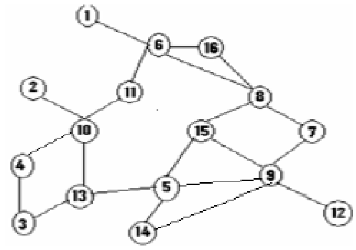

Fig. 2 MANET Nodes as transmission range

B. Clustering Maintenance

One way to predict the mobility of nodes is using the Node and Link Weighted Clustering Algorithm (NLWCA) [15]. The impact of mobility prediction schemes on the stability of the clusters obtained using a mobility-aware clustering framework. Compute the Time to Link (TTL) to predict the duration of a wireless link between two nodes in the network. The approach assumes that the direction and speed of motion of the mobile nodes does not change during the prediction interval.

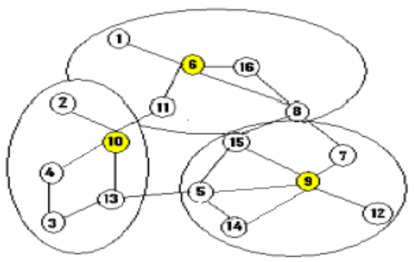

Fig.3. Cluster formation of nodes according to weight of each node

C. Time to Link (TTL)

The Time to Link (TTL) is a simple prediction scheme that determines the duration of a wireless link between two mobile nodes. Dynamic clustering in ad hoc networks has also been extensively studied in the literature. Several distributed clustering algorithms for MANETs have been proposed. While some schemes try to balance the energy consumption for mobile nodes, others aim to minimize the clustering-related maintenance costs. Combined metrics based clustering schemes take a number of metrics into account for cluster configuration. The Weighted Clustering Algorithm (WCA) [22] is one such scheme, where four parameters are considered for the cluster head election procedure, which are representative of the degree, the sum of the distances to other nodes in its radio distance, mobility, and battery power of the mobile nodes. Here we propose an enhanced WCA which can enhance the stability of the network. Such a scheme can be tuned flexibly the parameters to suit to different scenarios. To calculate the duration of link between two mobile nodes, we assume that their location, speed and direction of movement remain constant.

Here let:

- Location of node i and node j at time t be given by (xi , yi) and (xj ,yj).
- Vi and Vj be the speeds,
- θi and θj be the directions of the nodes i and j respectively.
- If the transmission range of the nodes is r, then the link expiration time Dt is given by the formula given below

$$D_i = \frac{-(ab+cd)+(a^2+c^2)r^2-(ad-bc)^2}{(a^2+c^2)}$$

Where

$a = v_i \cos\theta_i - v_j \cos\theta_j$

$b = x_i - x_j$

$c = v_i \sin\theta_i - v_j \sin\theta_j$

$d = y_i - y_j$

The TTL gives an upper bound on the estimate of the residence time of a node in a cluster. In the proposed clustering framework, when TTL-based prediction is used, a node is allowed to join a cluster only if the predicted TTL of the link between the node and the cluster head is greater than the cluster's admission criteria Tj [20, 21]. For every node N that detach from current cluster we check whether the node is a Cluster Head (or) Cluster member.

I. If it is a Cluster Head then call for cluster head election within the particular cluster and form a new cluster.

II. If it is a Cluster member then calculate Link Expiration Time with Cluster Head of each cluster and the node that re-affiliates must be within transmission range of cluster head where transmission range is fixed.

Check whether TTL is greater than threshold value (Tj), Here Tj is average of all TTL, and if it is greater than the Node is eligible to join the particular cluster which shares greater TTL.

IV. CONCLUSION

This proposed algorithm is a cluster based routing protocol for ad hoc network. This paper investigates the performance of different cluster head (CH) selections in MANETs. CH selection is examined by selects a set of CHs such that every node in the network is either a CH or is located within distance h hops away from the nearest CH. In this paper we have presented an enhanced weight based clustering algorithm using mobility prediction that can be applied in MANETs to improve upon their stability and to reduce re-affiliation of the nodes. Proposed method mainly focuses on reducing the instability caused by high-speed moving nodes, by taking relative mobility of node and its neighbors into consideration. Since WCA support stable cluster head election and the disadvantage is reaffiliation of nodes which is reduced by mobility prediction, it results in stable clustering.

REFERENCES

[1] E. W. Dijkstra, "Self-stabilizing system in spite of distributed control," Commun. ACM, vol. 17, no. 11, pp. 643–644, 1974.

[2] C. Johnen and L. H. Nguyen, "Robust self-stabilizing clustering algorithm," in OPODIS'06: Proceedings of the 10th International Conference On Principles Of Distributed Systems, 2006, pp. 408–422.

[3] Shuhui Yang, Jie Wu, Jiannong Cao, "Connected k-Hop Clustering in Ad Hoc Networks", 2005.

[4] Chinara, S., & Rath, S., "A Survey on One-Hop Clustering Algorithms in Mobile Ad Hoc Networks". Journal of Network and Systems Management, (PP. 183 – 207), 2009.

[5] AbdelRahman, Sufian Yousef "An Efficient Weighted Distributed Clustering Algorithm for Mobile Ad hoc Networks" Page No. 221-228, IEEE 2010.

[6] Junpei Kuroiwa, Yukiko Yamauchi, Weihua Sun and Minoru Ito, "A Self-stabilizing Algorithm for Stable Clustering in Mobile Ad-hoc Networks", 2011 IEEE.

[7] Na Zhang, Ningqing Liu, Meng Wu and Weixiao Meng, "Reseach on Mobile Hidden Station for Weighted Clustering Algorithm in MANET System", 6th International ICST Conference on Communications and Networking in China, Page 625-628, 2011 IEEE.

[8] Dongsheng Chen, Alireza Babaei and Prathima Agrawal, "An Efficient Cluster Update Model in MANET", 44th IEEE Southeastern Symposium on System Theory, Page 73-77, 2012 IEEE.

[9] 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, page 37-42, 2012 IEEE.

[10] Hui Cheng, Shengxiang Yang, "Genetic Algorithms with Elitism-based Immigrants for Dynamic Load Balanced Clustering Problem in Mobile Ad Hoc Networks", 2011 IEEE

[11] Mehta, S. Sharma, P. ; Kotecha, K., "A survey on various cluster head election algorithms for MANET", International Conference on Engineering (NUiCONE), Nirma University, Conference Publications, Page 1-6, IEEE 2011.

[12] Dongsheng Chen, Babaei, A., Agrawal P.,"An efficient cluster update model in MANET", Conference on System Theory (SSST), 2012 44th Southeastern Symposium, Page 73-77, 2012 IEEE.

[13] Na Zhang, Ningqing Liu, Qiyue Yu, "Improved RTS-CTS algorithm to solve mobile hidden station problem in MANET", Cross Strait Quad-Regional Radio Science and Wireless Technology Conference (CSQRWC), Page 812-815, 2011, IEEE.

[14] Chakraborty, U.K., Das, S.K., Abbott, U.T.E., "Clustering in mobile ad hoc networks with differential evolution", Congress on Evolutionary Computation (CEC), Page 2223 – 2228, 2011 IEEE.

[15] Andronache, A, Rothkugel, S. "NLWCA Node and Link Weighted Clustering Algorithm for Backbone-Assisted Mobile Ad Hoc Networks". Seventh International Conference on Networking, 2008, IEEE.

