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A Status based clusterhead election algorithms for mobile Ad Hoc Networks

Sunil Pathak and Sonal Jain
Computer Engineering Department, JK Lakshmipat University, Jaipur, India.

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ABSTRACT

We proposed a new status based clusterhead election algorithms for mobile ad hoc networks which are responsible for stable clusterhead election for a cluster and maintain a stable clustering by predicting staying time for a cluster and selecting an optimal clusterhead. In proposed method if there is two or more than two cluster heads are within the same radio range, initially clusterhead changes will be delayed up to delay timer. After delay timer expire if both the cluster heads are still in the same radio range, then old new clusterhead change its status from 0 to 1 and become as Clustermember within same cluster. In proposed method old clusterhead within the cluster has priority to act as clusterhead compared to other clusterhead which is coming from other cluster.

Introduction

Mobile Ad hoc networks (MANETs) are collection of Mobile nodes that intercommunicate on shared wireless channels. MANETs changes its topology due to mobility of wireless nodes. Existing nodes leaves network and new nodes joins the network from time to time. Such nodes has routing capabilities, each mobile nodes are connected by other nodes using multi hop paths connectivity.

Routing protocols for Mobile ad hoc networks can be divided into two main categories: Proactive or table driven routing protocols and Reactive or on-demand routing protocols. In Pro-Active routing protocol, it keeps routes to all possible destinations, that is, all nodes in the network so that paths can be found out quickly as and when required. Such protocol requires an overhead for maintaining and exchanging information about the state of the network. In reactive routing *protocol*, path discovery process starts only on demand of an application. These algorithms experience relatively lesser overhead but are characterized by larger delays.

A flat architecture exclusively based on table-driven or on-demand routing approaches cannot perform well in a large ad hoc networks [1][2][3]. A flat architecture based ad hoc networks encounters scalability problems with increased network size and with node mobility. The routing overhead of proactive routing protocols is $O(n^2)$, where n is the total number of mobile nodes in a network [4]. This shows that the routing overhead of such an algorithm increases with the square of the number of mobile nodes in a MANET. In case of a reactive or on demand routing, the RREQ (route request) broadcasting over the whole network and the significant setup delay become intolerable in the presence of both a large number of nodes and mobility. Clearly, some sort of a compromise needs to be achieved between the two schemes. Clustering tend to do that. Therefore, a cluster-based structure is essential for achieving a basic performance guarantee in a large and dense MANET.e head from the text.

Clustering and MANET

The objective of a clustering algorithm is to fabricate and preserve a connected cluster. Connectivity is defined as the probability that a node is available from any other node. A clustering algorithm comprise of two steps: In the first step new cluster is set up and in the second step the existing cluster will be maintained. Algorithms differ on the criterion for the selection of the Clustering Heads in the cluster set up phase.

Clustering is a popular technique in the area of distributed network computing. The aim of clustering has been twofold: First, to speed up computation by sharing information, local properties of a network are used, preferably inside a local group or cluster. Second, the overall load on the network is decreased by performing as much computation as possible locally and sending out data that in some sense represents all nodes in a cluster. As the load depends generally on the number of nodes in a group (which is not limited), hierarchical clustering is needed to make a protocol scalable.

In a clustering architecture scheme the mobile nodes in a mobile ad hoc network are divided into many overlapping or non-overlapping clusters [5]. Each formed cluster elects one node among the members as the clusterhead. Neighbors of any clusterhead cannot be clusterhead as well. Clusterheads communicate with each other through gateway nodes. A gateway node has two or more clusterheads as its neighbors-when the clusters are overlapping or at least one clusterhead and another gateway node – when the clusters are non-overlapping. Under a cluster structure, mobile nodes may be clusterhead, cluster gateway, or cluster member. A clusterhead acts as a local coordinator for its cluster and performs intra-cluster transmission arrangement and data forwarding. A cluster gateway has inter-cluster links and can access neighbor clusters and forward information between them. A cluster member is an ordinary node without any inter-cluster links.

Clustering can be normally separated into two phases, cluster formation and cluster maintenance. Cluster formation refers to how to build a cluster structure for a MANET at the very beginning. Cluster maintenance is about how to update the cluster structure according to the underlying network topology change during the operation.

Need of Clustering

A hierarchical (cluster-based) architecture provides at least three benefits over the flat architecture. First, a cluster-based structure facilitates the spatial reuse of resources to increase the system throughput. With the non-overlapping cluster structure, two clusters may use the same frequency or code set. Also, a

Tele:
E-mail addresses: sunilpath@gmail.com

cluster structure can better coordinate its transmission events with the help of a clusterhead. This can save much scare resources such as bandwidth used for retransmission resulting from transmission collision. The second is in routing, because the set of clusterheads and cluster gateways normally forms a virtual backbone for inter-cluster routing, and thus the generation and spreading of routing information is restricted among the set of clusterheads and cluster gateways. A cluster structure also makes an ad hoc network smaller and more stable. When a mobile node changes its attached cluster, only the mobile nodes needs to update the information. Thus, local changes need not to be updated by the entire network, and thus the information processed and stored by each mobile node is greatly reduced.

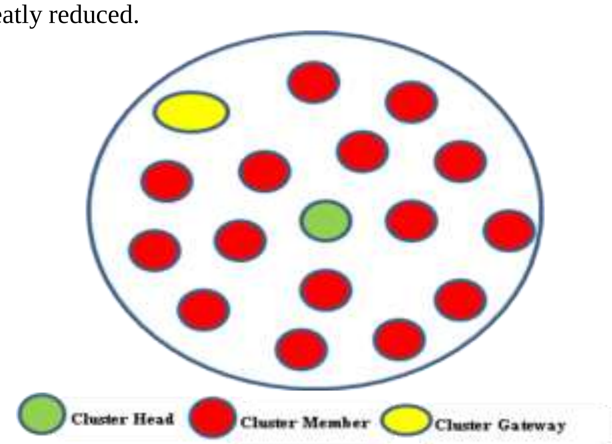

Figure 1. Structure of a Cluster

Cost of clustering

Cluster-based structure is important for a network to achieve scalability in the presence of a large number of mobile nodes and high mobility. However, a cluster-based MANET has its drawbacks because constructing and maintaining a cluster structure usually requires additional overheads compared with a flat-based MANET. The cost of clustering [6],[7] is a key issue to validate the effectiveness and scalability enhancement of a cluster structure. By analyzing the cost of a clustering scheme its usefulness and drawbacks can be clearly specified. The clustering cost terms are described as follows:

- Cluster-based structure requires explicit clustering-related information exchanged between node pairs. Clusters cannot be formed or maintained by non-clustering-related messages, such as routing information or data packets.
- Ripple effect re-clustering indicates that the re-election of a single clusterhead may affect the cluster structure of many other clusters and completely alter the cluster topology over the whole network.

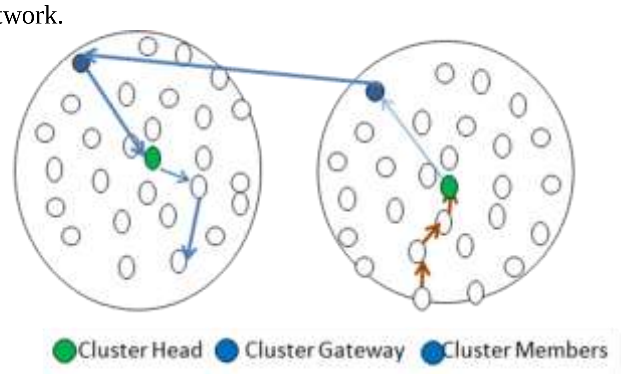

Figure 2 Exchange message between two clusters

- Mobile nodes must be static in the cluster formation phase so that mobile nodes are able to obtain accurate neighbor information and cluster structure can be promised with specific attributes.
- Computation round is the number of rounds that a cluster formation procedure can be completed. The non-constant computation round of a clustering scheme indicates its unbounded time complexity. Only clustering schemes that require the frozen period of motion assumption need to consider this metrics.
- Communication complexity represents the total amount of clustering-related message exchanged for the cluster formation [8]. For clustering with ripple effect, the communication complexity for re-clustering in the cluster maintenance phase may be the same as that in the cluster formation phase. But for those with no ripple effect, the communication complexity of re-clustering should be much lower.

The paper is organized into V steps which are as follows. In section I introduction and literature survey is explained for various clustering algorithms for mobile ad hoc network. Previous works related to various clustering schemes are explained in Section II. Section III covers proposed Status Based Clusterhead Election Algorithms (SBCEA) for mobile ad ho network. In section IV simulation various simulation parameter and performance matrices are described. Conclusion and future work is explained in section V.

Related Work

There are numerous research carried out on cluster maintenance algorithms for mobile ad hoc network by researchers. Each clustering algorithms has its advantages and disadvantages based on prescribed criteria. This section of paper focuses some of such clustering protocol for MANET.

a) **Lowest ID cluster algorithm (LIC): [9] In LIC each mobile node assigned arbitrarily numbers** which are known as Node *ids*. This node id number is responsible for cluster head selection process for a cluster. LIC algorithms work as below.

Step 1: Start
Step 2: If[Two Cluster Heads are With in Same
    Radio Range] Then
    If[New_Ch_Ids>Old_Ch_Ids) Then
        New CH force to release his role and
        become CM
        Else
        New Ch serves as CH
    End If
Step3: End If
Step 4 Stop

As we know that the node with smallest ids are more possible to act as a Clusterhead in a cluster for long time because node ids do not change with time. So the node with higher ids will not get chance to work as clusterhead for a cluster. Nodes with lowest ids are prone to power drainage due to serving as clusterheads for long time duration. In LIC Many clusterheads are elected time to time, if there is a clusterhead node movement or a node die condition in the cluster, re-clustering procedure is followed for clusterhead selection, No metrics has been taken into consideration like load balancing, battery power, mobility, size of the cluster etc.

a) Highest connectivity clustering algorithm (HCC) [10] in HCC The node with higher degree will be elected as clusterhead. The HCC algorithms works as below:

Step 1: Start
Step 2: Each mobile node broadcast its id to other
    nodes which are within its transmission
    range.
Step 3: The mobile node with maximum degree
    elected as Clusterhead
Step 4: Other mobile node which has less

maximum degree act as Clustermember.

Step 5: Stop

In HCC if two clusterheads are within the same transmission range or clusterhead moves from the existing cluster, then new clusterhead election is decided by calculating maximum degree. Degree of a node is computed based on its distance from others. HCC has a low rate of clusterhead change but the throughput is low. Typically, each cluster is assigned some resources which is shared among the members of that cluster. As the number of nodes in a cluster is increased, the throughput drops. The reaffiliation count of nodes is high due to node movements and as a result, the highest-degree node (the current clusterhead) may not be re-elected to be a clusterhead even if it loses one neighbour. All these drawbacks occur because this approach does not have any restriction on the upper bound on the number of nodes in a cluster. In HCC while election process of clusterhead, each mobile node flooding of control messages in the entire network to calculating maximum degree this increased network overhead. In HCC there is no limit on the maximum number of mobile nodes can group into a cluster. CHs are responsible to work as router for all mobile nodes within the cluster, so at clusterhead it becomes the bottle neck.

c) *Weighted Clustering Algorithm (WCA):* [11][12][13] clusterhead selection in WCA is carried out on the basis of number of mobile nodes into a network, transmission power of mobile node, battery power of mobile node and mobility factor of mobile node. Clusterhead election is only invoked when mobile node move or current clusterhead is not capable to cover all mobile nodes. Overload factor for WCA is a pre defined threshold. Total number of mobile node which can easily handled by a clusterhead is known as pre defined threshold for a cluster. Clusterhead election is carried out according to the weight value assigned for each mobile node.WCA selects the clusterheads according to the weight value of each node. The weight associated to a node Wv is defined as:

$Wv = w1\ \Delta v + w2\ Dv + w3\ Mv + w4\ Pv$ ------------------ (1)

The node with the minimum weight is selected as a clusterhead. Here weighting factors are chosen as

$w1 + w2 + w3 + w4 = 1$.......……………………………(2)

Mv is the measure of mobility and calculating by the average running speed of every mobile node during a specified time T.

Δv is the degree difference and obtained by first calculating the number of neighbours of each node. The result of this calculation is defined as the degree of a node v, dv. To ensure load balancing the degree difference

$\Delta v = |dv - \delta|$……………...............…………………..(3) Here δ is a pre-defined threshold.

Dv is defined as the sum of distances from a given node to all its neighbors.

Pv is the cumulative time of a node being a clusterhead. Pv is a measure of how much battery power has been consumed. A clusterhead consumes more battery than an ordinary node because it has extra responsibilities.

Proposed Status Based Clusterhead Election Algorithm (SBCEA)

The main objective of the proposed Status Based Clusterhead Election Algorithms (SBCEA) is to minimize the number of clusterhead change from a cluster. In this algorithms initially clusterhead changes is delayed up to delay_timer to avoid network overhead. Further algorithms work on the status of clusterhead and Clustermember for a cluster. Complete working of algorithms is described as below:

- Working of SBCEA totally depends upon the status of each mobile node. In Step 2 Old_Cm_Status for all member nodes of cluster are assigned by one (1) and Old_Ch_Status for clusterheads are assigned by zero (0) value.
- In Step 3 initially clusterhead changes are delayed up to Delay_Timer, because it may be possible that the mobile node is just moving across the cluster so clusterhead changes are not required.
- In Step 4 if both clusterhead are still in the same radio range then clusterhead changes take place according to step 4.
- New_Ch_Curr_Status:=0 represent that the mobile node will act as clusterhead and New_Ch_pre_Status:=1 represent that the mobile node will act as Clustermember.
- Old_Ch_Curr_Status:=0 represent that the mobile node will act as Clusterhead and Old_Ch_Pre_Status:=1 represent that the mobile node will act as Clustermember.
- Value of Delay_Period is the time required to send message from one mobile node to other mobile node within the cluster.

Clusterhead selection in SBCEA follow the following steps:

Step 1 Start

Step 2 [Initialization]

New_CH_Curr_Status:=0
New_Ch_Pre_Status:=0
Old_Ch_Curr_Status:=0
Delay_Timer:=Delay_Period

Step 3 If (Two CHs are within same radio range) Then
ClusterHead Changes will be delayed upto Delay_Timer
End If

Step 4 If (Is New_Ch is still in the range of Old_Ch) Then
New_Ch_Curr_Status:=1
Old_Ch_Curr_Status:=0
New CH force to release his role and become CM
Else
New_Ch_pre_Status:=0
New Ch serves as CH for the New Cluster
Old_Ch_Curr_Status:=1
Old Ch releases his services as CH and act as CM
End If

Stap 5 Stop

Input Parameters and Performance Metric

The proposed Status Based Clusterhead Election Algorithms (SBCEA) is implemented in *network simulator version 3* [14]. Node movement generator is used to create mobile node movement set up in network simulator. It used random way point model. Total number of mobile nodes, simulation area, simulation time, pause time, transmission range and speed of mobile nodes are given as input to node movement generator as input parameters. Simulation of Status Based Clusterhead Election Algorithms (SBCEA) is carried out by changing mobility of mobile nodes and speed of mobile nodes.

Table-I: Simulation Setup For Proposed Sbcea

Parameters	Value Set
Network Size	120
Simulation field	500m*500m
Simulating time	200 (s)
Pause time	0,50,100,150,200 (s)
Speed for mobile nodes	5,10,15,20,25 m/s
Transmission range	30m

To measure performance of proposed SBCEA over LCC and WCA is carried out by comparing total number of clusterhead changing and cluster overhead (number of messages sent by each node in the cluster to from a cluster head and to maintain clusterhead) by changing pause time and mobile node speed.

As figure 3 shows the clusterhead changes by varying pause time is low compare to LCC, HCC & WCA. As pause time increases in steps of 50 second, number of clusterhead changes also starts decreasing and when pause time is 200 second proposed SBCEA performed better compared to LCC, HCC and WCA.

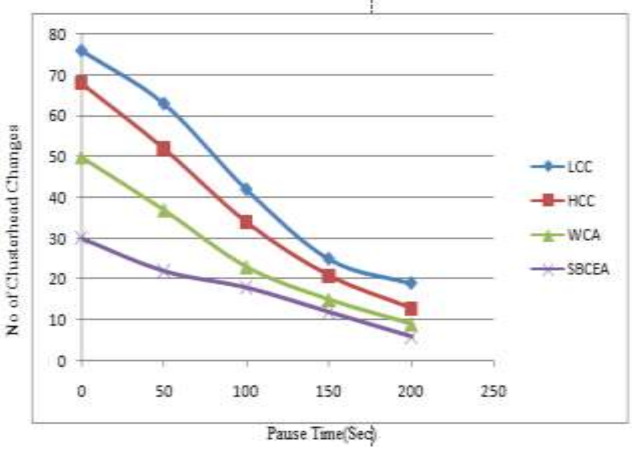

Fig. 3. Cluster Head change over pause time

In figure 4 as speed of mobile node start increasing, number of clusterhead changes also starts increasing because as a mobile node start moving with high speed within the simulation area, chance for clusterhead changes will be increase. Figure 2 shows that our proposed SBCEA method performed better as speed of mobile node increases over LCC, HCC & WCA.

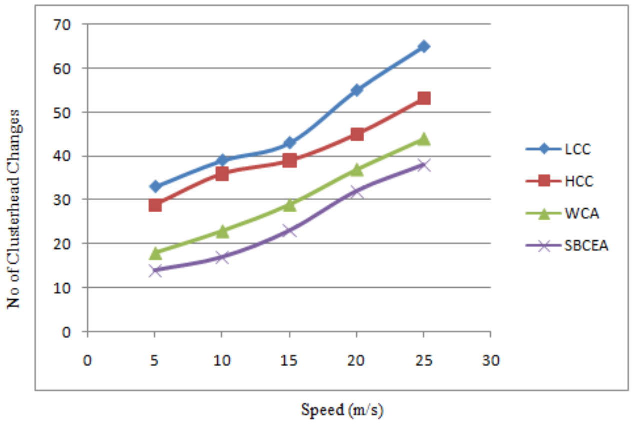

Fig.4 Clusterhead change over speed of mobile node

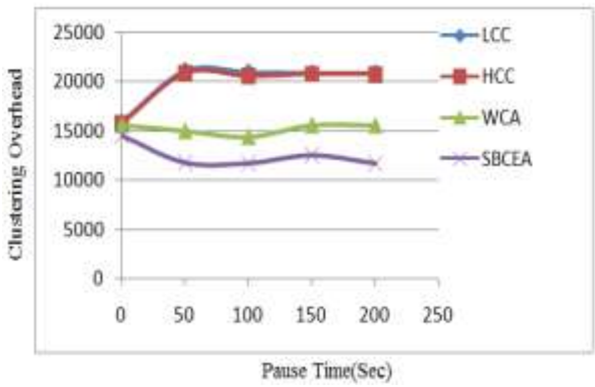

Figure 5 Clustering Overhead Vs Pause Time

From figure 5 and 6 it is clear that proposed SBCEA method perform better by reducing number of message exchange for clusterhead election in a cluster. In figure 5 initially clustering overhead for proposed SBCEA is near 15000k/b and as pause time increases clustering overhead decreases up to its last 11590 k/b when pause time reaches 200 second. Compared to LCC, HCC and WCA proposed SBEA is performed better by reducing clustering overhead by changing pause time and speed for mobile nodes.

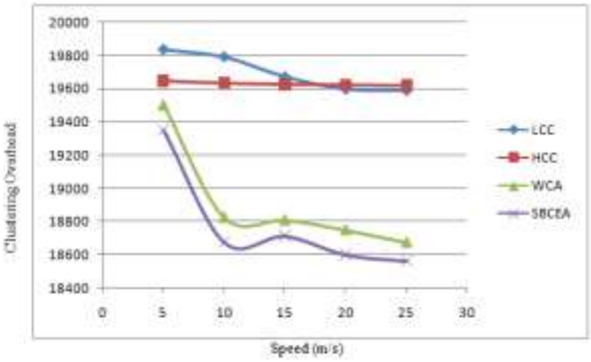

Figure 6 Clustering Overhead Vs Speed

Conclusion

This paper presents Status Based Clusterhead Election Algorithms (SBCEA) for mobile ad hoc network. From the simulated result it is clearly indicates that proposed SBCEA method perform better by reducing clusterhead changes and clustering overhead by changing pause time and speed for mobile nodes. Simulated results are compared with existing algorithms such as LCC, HCC and WCA. The main objective to proposed SBCEA is to reduced clusterhead changing to make cluster more stable and reduced clustering overhead. Because if a clusterhead changes very frequently from a cluster re-clustering process is required to elect clusterhead for cluster.

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