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Node Based Cluster Routing Algorithm for Mobile Ad-Hoc Network

Chaitali Uikey

School of Computer Science & IT, Devi Ahilya Vishwavidyalaya, Indore, M.P., India

Abstract: Mobility of node is an important subject at the time of clustering in mobile ad hoc network as it directly affects the strength of the cluster. MANETs clustering based algorithms commonly suffers with crash of cluster-head problem, which degrades the cluster stability. This paper proposes, Node Based Cluster Routing Algorithm (NBCRA), a schema to improve the cluster stability and in-turn to improve the performance, through selecting better cluster-head. In the algorithm, node itself observes and accounts its movement and this information is used to select cluster-head. Moreover, proposed protocol increases the stability of the cluster-head.

Keywords: MANET, Cluster, NBCRA, Cluster-head

I. INTRODUCTION

Mobile Ad-hoc Networks (MANET) is a collection of wireless nodes that self-configure to form a network without the aid of any established infrastructure. There are number of characteristics in mobile ad-hoc networks, such as the dynamic network topology, limited bandwidth and energy constraint in the network. Mobile ad hoc network is useful for different purpose e.g. military operation to provide communication between squads, emergency case in out-of-the-way places, medical control etc.

Recently, routing in MANETs has become one of the most challenging tasks [1]. Routing in networking is the process of selecting paths in a network to send network traffic. A number of routing protocols techniques have been proposed for use in MANETs such as Ad-hoc on demand Distance Vector Routing (AODV) [2], Dynamic Source Routing (DSR) [3], and Destination Sequence Distance Vector (DSDV) [4].

Clustering is an approach used to reduce traffic during the routing process. Clustering is division of the network into different virtual groups based on rules in order to discriminate the nodes allocated to different sub-networks. The goal of clustering is to achieve scalability in presence of large networks and high mobility. Roles of nodes in clusters are grouped in four categories namely cluster-head, gateway nodes, member nodes and guest nodes. Fig. 1 shows categories of nodes in cluster.

- Cluster-head: A Cluster-head node is the local coordinator of a cluster. The transmission range of cluster head describes the limitations of a cluster.
- Gateway Nodes: Gateway nodes are located at the boundary of the cluster. It can forward information between clusters.
- Member Nodes: Member nodes are also called as ordinary node. Member nodes are members of a cluster and these nodes have neighbours belonging to their own cluster.
- Guest Node: Guest node is a node associated to a cluster.

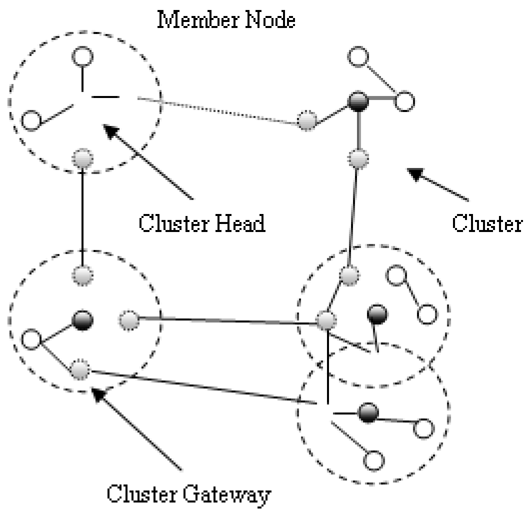

Fig. 1 Categories of Nodes in Cluster

Cluster-head maintains routing and topology information and passes it to other nodes. A member node does not maintain any routing and topology information or perform any routing functions, but can create a cluster heads bottleneck points in the network.

Cluster algorithms are classified into two types: active and passive cluster algorithms. In active cluster algorithm [5], by exchanging information nodes communicate with each other to select cluster-head, even if there is no data transmission. In passive cluster algorithm [6], clustering procedure is initiated only when data is transmitted. Passive clustering does not have major control on overheads as compared to active clustering, but, it requires larger setup time which is significant for time critical applications. This paper focuses on the MANET Node Base Cluster Routing Algorithm. Further, section 2 provides literature review of the related research works in the area of cluster routing algorithm. Section 3 explains method and flowchart of proposed algorithm; in while section 4 details of the simulation with results are discussed and section 5 overviews conclusions drawn from the obtained results.

II. LITERATURE REVIEW

Smooth and Efficient Re-Clustering (SERC) protocol [7] proposed a new method to improve cluster stability. In SERC, every cluster-head is known as primary cluster-head (PCH). Each PCH selects secondary cluster-head (SCH). When PCH is no longer a cluster-head then SCH will act as the cluster- head. Since SCH is known to all cluster members, the cluster leadership will be transferred effectively. Each node has four battery power levels. When battery power of PCH is at critical threshold, it transfers its responsibilities to SCH. This approach improves cluster stability and reduces cluster communication overhead.

The Highest Degree Algorithm [8] is based on the connectivity between various nodes. The degree of a node is the number of direct neighbor that node have .Each node periodically broadcasts its degree value in hello messages. A node compares the degree value of its neighbors with its own value to decide to become a cluster-head. The node having the highest degree value in its neighborhood will become a cluster-head.

Weighted Clustering Algorithm [9] describes network formation in following way. The network is formed by the nodes and the links, which can be represented by an undirected graph G = (V, E), where, V represents the set of nodes and E represents the set of links. Note that, the cardinality of V remains the same but the cardinality of E always changes with the creation and deletion of links. Clustering can be thought as a graph partitioning problem with some added constraints. As the underlying graph does not show any regular structure, partitioning the graph optimally (i.e., with minimum number of partitions) with respect to certain parameters becomes an NP-hard problem.

The Lowest-ID Algorithm [8] is the simplest clustering algorithm .In this algorithm every node in the network has a unique identifier (ID). Nodes periodically broadcast their ID in “hello messages”. Each node compares the IDs of its neighbors with its own ID, than a node having lowest ID decides to become a cluster head.

In the Distributed Clustering Ad-hoc (DCA) algorithm [10] is executed at each node with the sole knowledge of the executing node's unique identifier (ID), its weight, and information of its neighbors. The algorithm is distributed and relies only on local information.

III. PROPOSED METHOD

A. Parameters

The proposed algorithm takes four parameters for selecting cluster-head namely, degree of the node, battery power, transmission power, and stability of the node.

- Degree of the Node (DN): It is the number of neighbour’s node which is present within its transmission range.
- Battery Power (BP): Defines the amount of battery power has been consumed.
- Transmission Power (TP): It is used to select the node which can cover the largest area.
- Stability of Node (SN): It defines mobility of nodes, which is depending upon its mobility pattern.

These parameters are used to calculate the ability of nodes, and the node having maximum ability is selected as cluster-head.

$$Ability={}_{w}DN+{}_{w}BP+{}_{w}TP+{}_{w}SN$$

Where, SN= no of old nodes – no of new nodes

The coefficient w is the weighting factor for the corresponding system parameters by default its value is 1.

B. Cluster-head Selection Process

Each and every mobile node transmits first LIVE message to the all others nodes. After receiving LIVE message, every mobile nodes count how many number of LIVE message is received and the sum of the value is considered as the degree of the node. After counting degree of node, all nodes transmit their REPLY LIVE message to all other nodes with value of all parameters. When network is established for the first time, the initial value of stability of node is zero. After getting second LIVE message each node calculate ability for their neighbouring nodes using the following equation:

$$Ability_{(MAX)} = ({}_{w}DB_{bm}-{}_{w}DB_{am})+({}_{w}BP_{bm}-{}_{w}BP_{am})+({}_{w}TP_{bm}-{}_{w}TP_{am})+({}_{w}SN_{bm}-{}_{w}SN_{am})$$

Where ${}_{w}DB_{bm}$, ${}_{w}BP_{bm}$, ${}_{w}TP_{bm}$ and ${}_{w}SN_{bm}$ are degree of node , battery power, transmission power and stability of node before movement on which ability is being calculated and ${}_{w}DB_{am}$, ${}_{w}BP_{am}$, ${}_{w}TP_{am}$ and ${}_{w}SN_{am}$ are values of the node which has sent the LIVE message after movement.

If all the $Ability_{(Max)}$ value at a particular node are negative then the particular node will declare itself as a cluster-head otherwise highest $Ability_{(Max)}$ node will be selected as cluster-head. In case of more than one node having equal $Ability_{(Max)}$, lowest $_{ID}$ node will be selected as cluster-head. After selecting cluster-head each node transmit LIVE message to all other nodes that contain information about cluster-head.

The given flowchart in Fig. 2 shows the selection of cluster-head.

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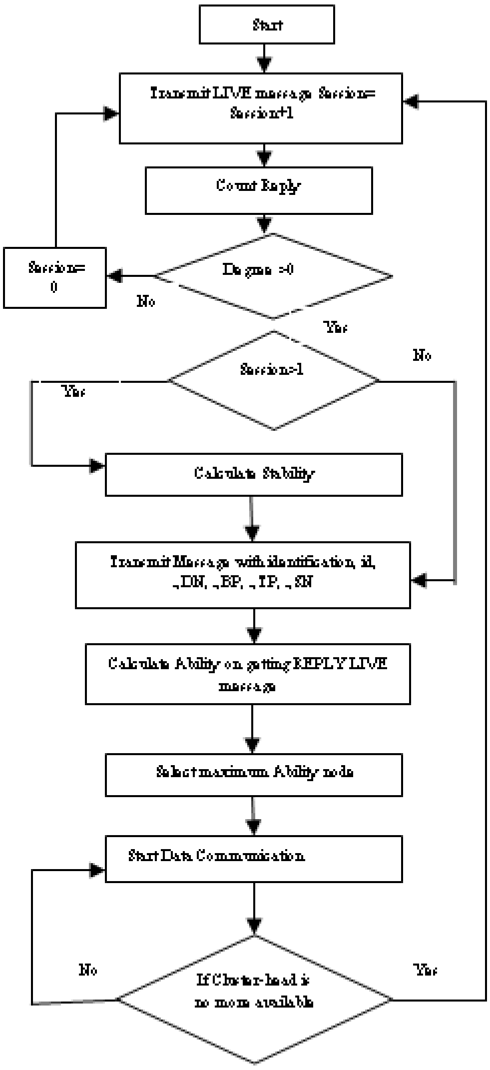

Fig. 2 Flowchart for Cluster-head Selection

IV. RESULT & ANALYSIS

This section describes the working and performance of the algorithm which is simulated on the NS2 simulator.

A. Find cluster-heads and their cluster members.
B. Analysis of no of cluster-head changes between WCA [9] and (Node Based Cluster Routing Algorithm) NBCRA.
C. The performance of AODV, DSR, and DSDV routing algorithms which is based on node based cluster algorithm is evaluated in term of congestion.

The algorithm is simulated for 50 mobile nodes spread randomly in a 600m * 400m area network; transmission range for each node is 100 meters. Mobiles nodes are positioned randomly on the plane. Nodes start its journey from a random location to a random direction with a random speed.

Parameter	Value
Number of nodes	50
Size of network	600*400
Speed of the nodes	0-15m/sec
Transmission rang	100m
Battery power of node	100 unit

Table 1 Simulation Parameter

A. Find cluster-heads and their cluster members

Clusterhead	Member Nodes	Gateway Nodes
5	1,2,3,4,40	2,40
8	6,7,9,10,	10
11	12,13,14,,15,16,10,	12,13
17	18,19,25,26,28,30,35,38	26,35
24	20,21,22,23,27,33,2	2
39	34,36,37,40,41,42	37,40
49	43,44,45,46,47,48,50	43,45,50

Table 2 Cluster-heads and Members

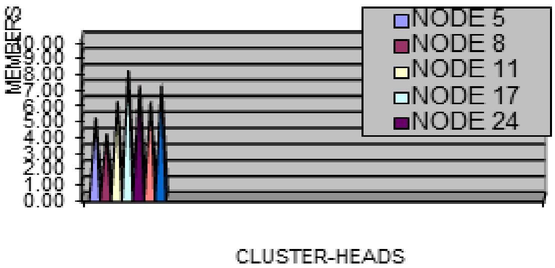

Fig. 3 Cluster-head vs. Members

The table 1, 2 and Fig. 3 shows all the network nodes that are involved in clusters and nodes that are isolated from the network, along with those nodes which can hear broadcast from other clusters and serves as gateway node.

A. *Analysis of no of cluster-head changes between WCA and NBCRA.*

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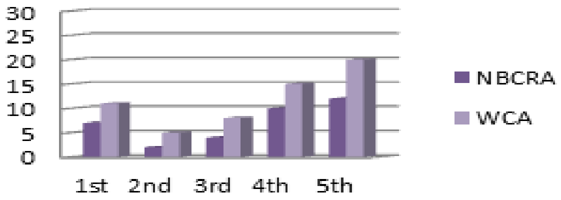

Fig. 4 Averages number of member per cluster are about 5 members

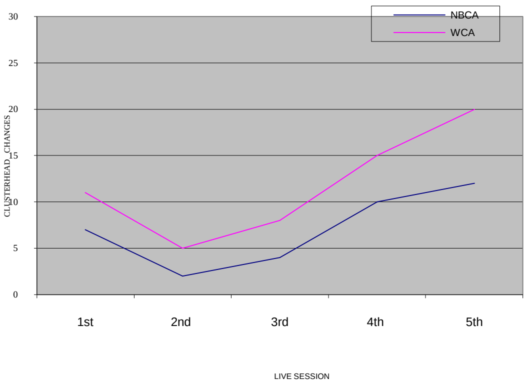

Fig. 5 Chart for Cluster-head Changes

The proposed algorithm NBCRA suggests an improvement over the existing algorithm WCA Fig 4 & 5 show cluster-head changes in the network containing 50 node and random mobility results are calculated for five sessions, these chart shows that there are less cluster-head changes in NBCRA than WCA. Less number of cluster-head changes results in less resource like battery and bandwidth usage in cluster-head selection procedures.

B. *Analysis of congestion in clustered environment using different routing protocols.*

Fig 6, 7, and 8 shows the congestion analysis in routing protocol and Fig. 9 show that DSR protocol provides best results with lowest congestion, DSDV have highest congestion rates and AODV falls between the two.

V. CONCLUSION

The proposed clustering algorithm is having three factors which are mostly responsible for rapid cluster-head changes, namely battery power, stability and connectivity. The purpose of the paper was to study the clustered environment and to identify an energy efficient clustering algorithm. This has been achieved by the proposed algorithm as it provides highly stable cluster due to selection of less mobile nodes as cluster heads. Less number of control messages is needed to be passed due to high stability, resulting in better efficiency. The algorithm can be enhanced by adding some more features like group mobility detection and prediction, node mobility and network structure prediction and improved energy efficiency by transmission range optimization.

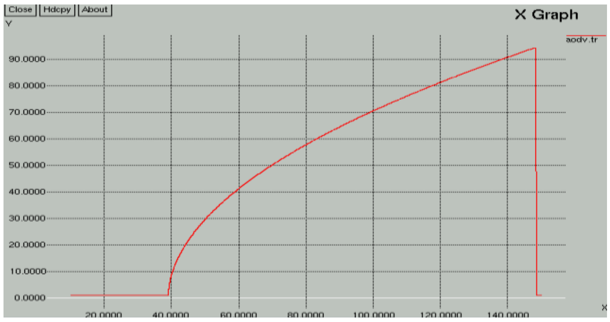

Fig. 6 Congestion Graph for AODV

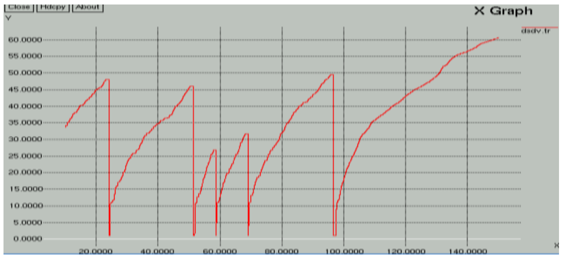

Fig. 7 Congestion Graph for DSR

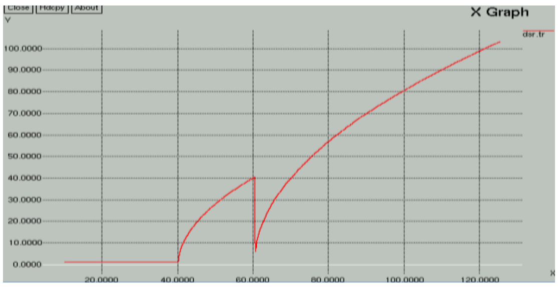

Fig. 8 Congestion Graph for DSDV

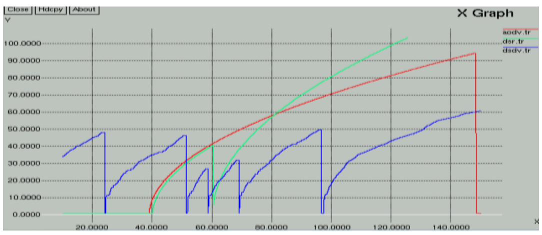

Fig.9 Congestion Graph for Protocols AODV, DSDV and DSR together

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