Modified Lowest ID Algorithm for Practical Wireless Clustered Network

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Abstract— Efficiency of the Lowest Node ID (LNID) clustering algorithm has been assessed in this paper. In the article we proposed the LNID clustering based on the classical Lowest ID algorithm. The proposed algorithm has the following crucial features: stabilizing procedures, ability to change the state during work, a state machine with semi-stable states and MAC address as ID nodes. Tests have been done for static network assuming Free Space Path Loss propagation model with assumed reliability of information delivery ratio link. The performance of this algorithm is evaluated through simulation and results are promising.

1. INTRODUCTION

Clustering is a promising approach for building hierarchies and simplifying the routing process in mobile ad-hoc network environments. The main objective of clustering is to identify suitable node representatives, i.e., Cluster Heads (CHs), to store routing and topology information and maximize clusters stability. Traditional clustering algorithms suggest CH election exclusively based on node IDs or location information and involve frequent broadcasting of control packets, even when network topology remains unchanged [1].

Clustering in MANET networks has many advantages compared to the traditional networks [8]. It allows the better performance of the protocol for the Medium Access Control (MAC) layer by improving the spatial reuse, throughput, scalability and power consumption. It also saves energy and communication bandwidth in ad-hoc networks. In cluster formation phase, CHs are selected among the nodes to form clusters, Figure 1.

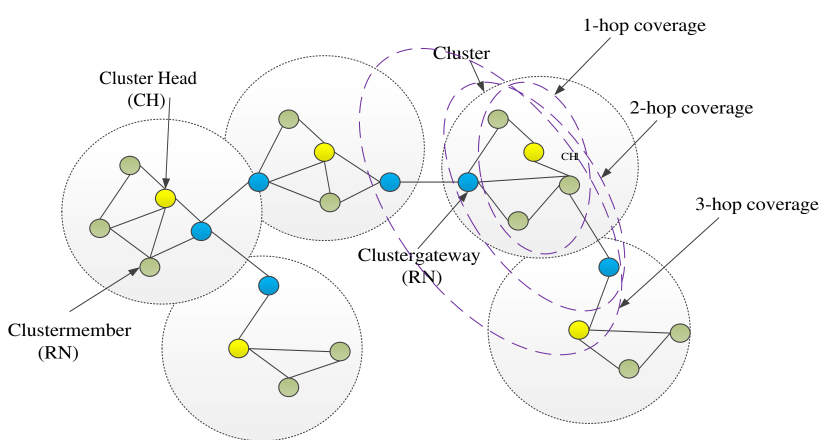

Figure 1: Clustered network.

2. RELATED WORKS

Many clustering algorithms based on different optimization objectives have been proposed. The goal of the Highest-Degree algorithm [2] is to minimize the number of clusters, which is achieved as follows. Each node is aware of the number of its neighbour nodes, which acquired by interactively exchanging control messages. The node having the highest number of neighbours, i.e., the highest degree, is elected as the cluster-head. If the degree of several nodes is the same, the lowest-ID node becomes the cluster-head. Then the one-hop neighbour nodes of the cluster-head become ordinary members of the cluster. The above procedure is then repeated until all nodes are form the clusters. The number of cluster-heads is relatively low in this algorithm, hence it potentially reduces the average number of hops between the source node and the destination node. In the Linked Cluster

Algorithm (LCA) [4], a node becomes the CH if it has the highest ID among all nodes. In the Distributed Clustering Algorithm and Distributed Mobility Adaptive Clustering Algorithm [12] weights are assigned to the nodes based on the suitability of node being a CH. The node is chosen to be a CH if its weight is higher than any of its neighbor's weight and any tie is broken by the minimum node IDs. The method works well for "quasi-static" networks where the nodes do not move much or move very slowly.

3. MODIFICATION OF LID ALGORITHM

The main asset of Lowest ID method is its implementation simplicity [3]. LID is an algorithm in which a node with the minimum ID is chosen as a CH. Thus, the IDs of the neighbors of the CH will be higher. A node within the transmission range of two or more CHs is called a GW, otherwise, a node is a Regular Node. Gateway nodes are generally used for routing between clusters. Each node has assigned a distinct ID. Periodically, the node broadcasts the list of nodes that it can hear (including itself). The Lowest-ID scheme concerns only with the lowest node IDs which are arbitrarily assigned numbers without considering any other qualifications of a node for election as a CH. Since the node IDs do not change with time, those with smaller IDs are more likely to become CH than nodes with larger IDs. Thus, certain nodes are prone to power drainage due to serving as CH for longer periods of time, which is important drawback of lowest ID algorithm.

In contrast to the Lowest ID algorithm, we proposed a modified clustering algorithm, the Lowest Node ID (LNID). This algorithm has the following crucial features:

- a state machine with semi-stable states,
- ability to change the state during work,
- additional control messages (as development of original OMNET messages),
- MAC address as ID of nodes,
- stabilizing procedures.

In the proposed algorithm, we defined four possible states for each node: Not Defined (ND), Regular Node (RN), Gateway (GW) and Cluster Head (CH), shown in Figure 2. We also assume the existence GW node for more than two CHs.

Possible transitions of a node are as follows:

- all nodes are in ND state at the beginning,
- if node has the lowest MAC address, it changes its status to CH,
- if node received Hello message from a CH, it changes its status to RN,
- if node is within transmission range of minimum two CHs, it changes its status to GW.

Also in contrast to the Lowest ID algorithm, all communication between nodes in our algorithm use only a *Hello* message. The *Hello* message includes the information such as: own and my neighbors node state (ND, RN, GW or CH) and node MAC address.

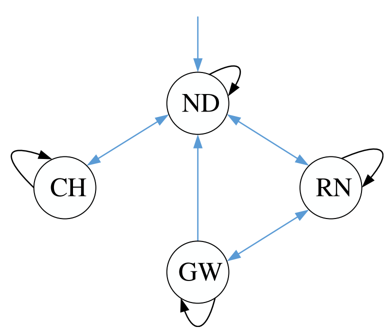

Figure 2: The transition diagram for each node.

The clustering procedure has two stages. The first one is the nomination stage, during which, all nodes changes its status. The second one is the gateway reduction stage, during which, all nodes in GW state checks the number of GW in the network. A large number of CH and GW nodes in the network is the one of the major drawbacks of clustering in MANETs [7]. Some nodes consume more power to compare to the others nodes in the same cluster. As special node like a CH or a GW node manage and forward all messages of the local cluster their power consumption will be high in comparison to RN. During the gateway reduction stage it is checked the condition whether more than one GW node between the same pair of CHs exist. If such condition is fulfilled, nodes with the smallest power received (average value) from CH, changes its status to RN. This procedure is necessary, to limit the number of GWs, because of consumed energy (GW node have to work in more than one cluster). Furthermore we defined the stop function of clustering algorithm. This function is fulfilled when assumed percentage (e.g., 99%) of the nodes in the all network, is in a state other than ND. The main differences between LID and LNID algorithm are shown in Table 1.

Table 1: Main differences between LID and LNID algorithm.

Feature	**Algorithm**		**Comments**
	Lowest ID (classical)	**Lowest Node ID (modified)**	
Simple procedure	✓	✓	Nodes with the smallest ID is the CH
Stabilizing procedures		✓	This metric allows to determine a “nervousness” of the algorithm
A state machine with semi-stable states		✓	Better readability of the algorithm;
Node can change a state during work	✓	✓	Ability to work in a different environment
Clusterization correctness metric		✓	Allows to assess the effectiveness of the algorithm
Structure stability of clusterized network metric		✓	

4. PERFORMANCE EVALUATION

In order to determine of the proposed solutions we conducted experiments using a computer simulation technique. We selected the OMNeT++ simulation environment [6].

4.1. Experimental Setup

The prepared network model consists of fixed number of static radio nodes, ranged from 150 to 300 in steps of 25 and located randomly in the square area of 50 km side length. All nodes can send and receive the radio frames with path loss and transmission delay proportional to a mutual distance. We used the following metrics to assess the efficiency of the algorithm:

- *Time of clusterization process,*
- *Energy used by the network in clusterization process,*
- *Clasterization correctness,*
- *Structure stability of clusterized network.*

4.2. Experimental Results

Simulation results are shown in Figures 3–5.

In the Figures 3 and 4 we can see, dynamic state change, during the clusterization procedure. We can see that the clusters are stable and every node knows its role in the network. The Figure 4 shows the number of state changes during clusterization procedure. We can see, that number of ND nodes decreases to zero. According to the interference level, it is known that the level of intersystem interference is proportional to a cluster size, frequency, and the sum of transmitted power. Concluding from differences in energy observed in Figure 5, consumed energy used during the clusterization procedure is generally dependent on clusters size. It can be proved that if clusters are smaller, the capacity of system is higher which id directly connected with intersystem interferences level.

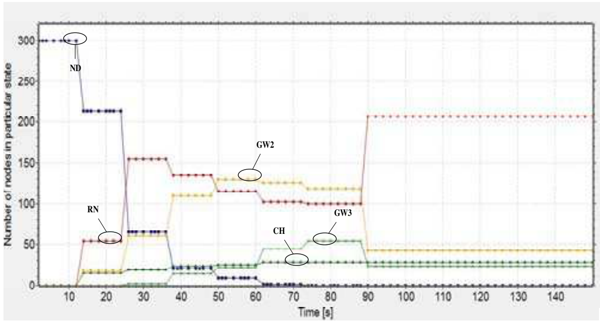

Figure 3: Number of nodes in particular state in function of Time.

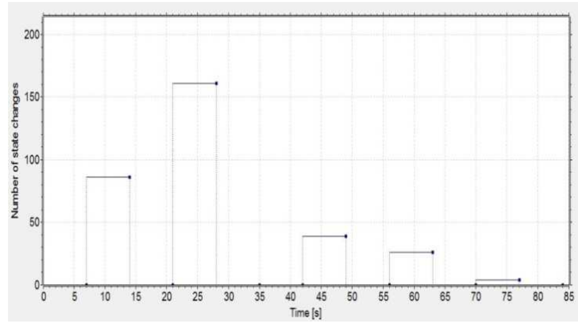

Figure 4: Number of state changes in function of Time.

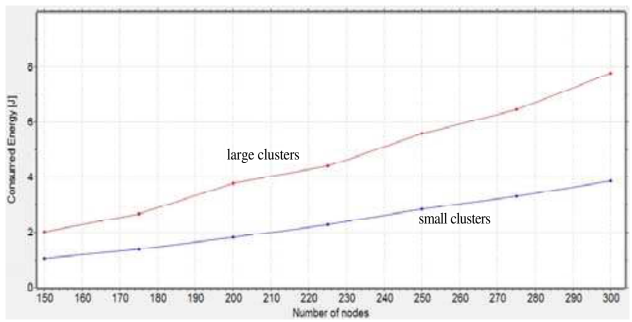

Figure 5: Consumed energy during clusterization procedure.

5. CONCLUSIONS

In this paper we proposed modified Lowest Node ID clustering algorithm to establish a stable clustering architecture. The proposed algorithm has a hierarchical structure that can maintain a stable topology of MANET, thereby optimizing network performance and making efficient resource allocation for nodes. One of the main advantage of LNID is its simplicity. It has to be verified in more realistic radio channels when nodes are moving e.g., discussed in [10, 11].

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