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A node quality based clustering algorithm in wireless mobile Ad Hoc networks

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Abstract

A new strategy for clustering a wireless AD HOC network is proposed. The main contribution of our work is to improve Weighted Clustering Algorithm (WCA) [5] and other similar algorithms. In literature, the node degree is considered as an important weight metric in clusterhead selection process. Unfortunately, this metric is not consistent especially when it is considered separately at the node environment such as the neighbours' location within the transmission range zone of this node. To overcome this inefficiency, we propose two new models. Thereafter, we combined these two models to take profit of their efficiencies. The new combined model, motivates us to generate and reformulate many node degree based formula given in literature and dealing with Quality of Clustering (*QoS*) as stability and load balancing clustering parameters. We showed that our algorithm outperforms WCA in the in terms of cluster formation and stability.

Keywords: ad hoc networks, clusters; load balancing; stability;

1. Introduction

Wireless ad hoc networks are multi-hop, self-organizing autonomous networks, composed of some mobile terminals including radio receivers and transmitters [1]. Wireless ad hoc networks do not rely on any existing or predefined network infrastructure, and terminal nodes randomly dispose [1]. Nodes within transmission range can communicate directly with each other. Nodes outside the transmission range must communicate indirectly using a

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multihop routing protocol. Individual nodes are responsible for dynamically discovering the route. Instead many clustering schemes have been proposed to organize the MANET into a hierarchy with a view to improve the efficiency of routing [2]. Clustering means a way to reconfigure all nodes into small virtual groups according to their regional vicinity and is defined as Cluster Head (CH) and cluster members that are determined with the same rule. Every clustering algorithm consists of two mechanisms: cluster formation and cluster maintenance [2].

In [2], the authors have proposed a combined weight clustering algorithm to establish a stable clustering architecture. The proposed algorithm has a hierarchical structure that can maintain the topology of MANET as stable as possible, thereby optimizing network performance and making efficient resource allocation for nodes. This makes it possible to maintain efficient and stable topology in MANET environment. In our algorithm, the node with the highest fitness is elected as the CH. In the proposed algorithm, due to the weight group, cluster creation is done very quickly which causes network services to be more accessible.

In [3], the authors proposed a sservice discovery architecture based on clustering in the Cluster-Based Service Discovery Protocol for Mobile Ad-hoc Networks. It performs the CH selection by allotting a combined weight value based on the factors power level, connectivity and stability, intended for wireless mobile ad hoc networks. The proposed method permits the switch over of service discovery messages only among the cluster members. It also considers the capabilities of the nodes for the distribution of workload.

In [4], the authors introduced a new type of algorithm called Enhancement on Weighted Clustering Algorithm [EWCA] to improve the load balancing, and the stability in the MANET. The CH is selected efficiently based on these factors like high transmission power, transmission range, distance mobility, battery power and energy. Since the CH will not be changed dynamically, the average number of cluster formations will be reduced.

A weight based distributed clustering algorithm (WCA) which can dynamically adapt itself with the ever changing topology of ad hoc networks is proposed in [5]. In this approach, the number of nodes is restricted to be catered by a CH, so that it does not degrade the MAC functioning. It also has the flexibility of assigning different weights and takes into account a combined effect of the ideal degree, transmission power, mobility and battery power of the nodes.

In [5], we observed that all nodes have the same chance to participate in the CH selection process, which affects the quality of the formed clusters. The motivation for the present work is to prioritize only some favorable nodes in this process. Consequently, we introduce our models to overcome the previous inefficiencies.

In the remainder of this paper, Section 2 presents problem specifications. Our algorithm models are given in Section 3. Section 4 illustrates clustering quality. The formal definition of our algorithm and its illustrative example are provided in Section 5. Conclusions are given in Section 6

2. Network model and problem specifications

As defined in [5], the network formed by the nodes and the links can be represented by an undirected graph $G = (V, E)$, where V represents the set of nodes v_i and E represents the set of links e_i. Note that the cardinality of V ($|V|$) remains the same but $|E|$ always changes with the creation and deletion of links. Clustering can be thought of 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 [6]. The neighborhood $\Gamma(v_i)$ of a CH v_i is the set of nodes which are directly linked to it and which are in fact the nodes lying within its transmission range (R_{v_i}). This defines the degree of the node $\boldsymbol{v_i}$:

$$\Gamma(v_i) = \{v_j,\ such\ that\ \ dist(v_i, v_j) < R_{v_i}\} \tag{1}$$

where $dist(v_i, v_j)$ is the measured average distance between v_i and v_j. Similar to [5], when a system is initially brought up, every node broadcasts its id which is registered by all other nodes lying within *its* transmission range. It is assumed that a node receiving a broadcast from another node can estimate their mutual distance by measuring the ratio of receiving power and transmission power. The node degree of a node v_i is deduced as the cardinality of the set $\Gamma(v_i)$: