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Mobility Aware Loose Clustering for Mobile Ad hoc Network

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Abstract

Mobile ad hoc network comprises of nodes that may often possess dissimilar characteristics. These characteristics include computation power, transmission range, battery backup, etc. Such heterogeneity makes the wireless channel asymmetric due to presence of some unidirectional links. The more powerful nodes enhance the scalability, coverage area, and network lifetime. However, the interference caused by the high power nodes may result in reduced throughput. An effective clustering algorithm renders longer cluster lifetime and incurs low maintenance overhead. However, the mobility of nodes adversely affects the hierarchical structure. Therefore, selecting quasi-mobile nodes for the role of cluster head is a preferred option that makes the clustering structure more stable. In the proposed algorithm, we present a stable loose clustering algorithm by considering more powerful however less mobile nodes as cluster heads. The simulation analysis confirms that our algorithm delivers more stable clusters with low maintenance effort.

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Keywords: Clustering; Mobile ad hoc networks (MANETs); Heterogeneous; Stable; Low maintenance.

1. Introduction

Rapid development in hardware and wireless technology and availability of small low power devices put forward the deployment of infrastructure less network anywhere anytime. The wireless network comprising mobile devises deployed for a special purpose is termed as Mobile Ad hoc Network (MANET). Self-configuration and lack of centralized control make the management of MANET more difficult. Furthermore, scalability is a critical concern among various other challenges in the MANET. Large number of nodes competes for limited bandwidth in wireless network. The size of routing table grows with the increase in number of nodes. One prominent approach for overcoming the scalability problem is clustering. Abstracting the network topology into different hierarchies of nodes is termed as clustering. Easy administration is another offshoot of clustering.

The clustering algorithm divides the large network into smaller virtual subsets that satisfy certain property. It works in two stages; in the initial phase the nodes are divided into groups and in the later phase efforts are made to maintain the structure created in first phase[2]. In any clustering algorithm, first phase is initialization and later on the maintenance procedure is invoked repeatedly to avoid the complete deterioration of the structure created before. The frequent invocation of second phase incurs higher overhead. By making the initialization phase highly stable one can reduce the number of invocation of maintenance phase. Because of the high cost of reclustering, stable clustering algorithms

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have gain more attention in recent years. The mobility of nodes plays an important role in cluster stability. Mobility causes a node to frequently join and leave a cluster. As a result, clustering algorithms for MANETs are designed to be adaptive towards node mobility. However, many of the algorithms presented before have not taken mobility into consideration and thus make the cluster unstable.

Most of the existing clustering algorithms assume network comprising of homogeneous nodes where all nodes have the same capabilities and resources[2]. However, heterogeneous network became more popular in recent years as they exhibit high scalability and capacity unlike the existing homogeneous networks. The heterogeneous network consists of nodes with different capabilities. The algorithms that are designed for homogeneous network may not deliver matching performance with the heterogeneous network as the heterogeneity of nodes has not been exploited in such algorithms.

A cluster head based clustering algorithm initially selects a node as a cluster head and then the neighbourhood of the selected node and itself forms a single cluster[4]. As the cluster head is assigned the additional responsibility to manage the cluster, the energy depletion of cluster head occurs faster and cluster head may become bottleneck or may even quickly run out of power. Selecting the comparatively high capacity node as cluster head avoids the early death of cluster head.

Depending on the number of nodes that take part in clustering, clustering can be divided into two types; tightly coupled clustering and loosely coupled clustering[3]. As the name suggests, in tightly coupled clustering every node in the network may assume any of the three roles; cluster head, cluster member or gateway. On the other hand, loosely coupled clustering does not impose such stringent condition. The less stringent the clustering condition the less will be the maintenance overhead.

In the present paper we proposed a mobility aware loose clustering algorithm for power heterogeneous MANETs. It is compatible with any kind of heterogeneous networks. Our work considers heterogeneity in transmission power. The algorithm can be extended to other type of heterogeneous network by considering other characteristics in order to select the capable node as cluster head. As we have considered the relative mobility and transmission power of nodes for cluster head selection, the stability of cluster has been improved compared to LVC algorithms. The simulation results confirm that the high transmission range of the cluster head leads to reduction in the number of clusters. In our experiment we have compared our result with the existing loose virtual clustering algorithm[3] and it was observed that the proposed algorithm is more stable.

The rest of the paper is organized as follows. In section 2 we have reviewed the existing algorithms and then in third section we have given the proposed algorithm. Section 4 explains the implementation details and comparison with existing approaches. Section 5 describes the cost of clustering and section 6 concludes the paper.

2. Related Work

Various methods have been proposed to address the clustering problem in mobile ad hoc network. Lowest Id [LID][4] clustering is one of the classic algorithms for clustering the network. In LID, every node in the network is identified by a unique value. Each node broadcasts its Id to its neighbors in every Hello interval. The lowest Id node among the neighborhood is elected as cluster head; the cluster head and its neighbors form a single cluster. The clustering method appears to be simple but it forms more number of clusters and also it is not suitable for interval and triangle graph[8]. Another classic approach is Highest Degree clustering [HD][5]. In this approach every node is notified about the degree of its neighbors periodically. The node having highest degree among the neighborhood is selected as the cluster head; its one hop neighbors forms the cluster members. According to some studies the number of clusters formed by HD is less compared to LID. Due to the continuous depletion of energy from the lowest id node in LID[4], Gavalaz *et al.* proposed a LIDAR[6] algorithm thereby the id of nodes are reassigned to make the cluster stable.

Most of the algorithms for clustering forms one hop cluster where every node is at most one hop away from its cluster head. As the area covered by the one hop cluster is less some authors have proposed k-hop clustering algorithms[6,8] where every member node is at most k-hop away from its cluster head. The idea of k-hop cluster was proposed at first by Krishna *et al.*[7]. The algorithm defines cluster as a set of nodes which are mutually reachable within k-hops. In[8], the node with highest degree among its k-hop neighborhood assumes the role of cluster head. The cluster head and its k-hop neighbors form the cluster. In case of tie i.e. two nodes with highest degree, the node with lowest id among the