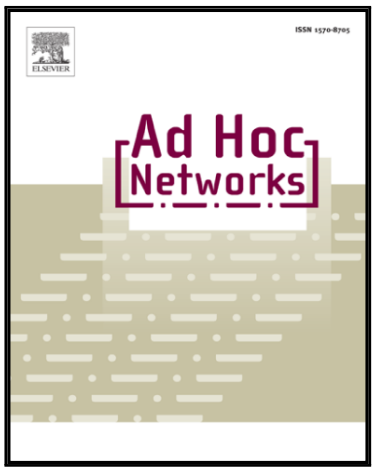

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On State Maintenance in Cluster-Based Mobile Ad-hoc Networks

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Abstract

Clustering is an effective strategy for tackling the dynamics and scalability in a large-scale mobile ad hoc networks (MANETs). However, the mobility of the nodes makes it very difficult to maintain the states of the clusters, such as connectivity between clusters, available bandwidth, and node membership. A good maintenance scheme should balance the workload and power consumption of the nodes, incur little overhead, and track the changes timely and accurately. For this, we consider the implementation of a maintenance sublayer to handle the dynamic state of the clusters. The idea is to hide the dynamics of the underlying clusters, to improve the performance of applications in MANET. In this paper, we examine the design space of the state maintenance problem in cluster-based MANETs. At one end, we study a fully distributed approach, called Cluster-Based WithOut Head Overlay (CWOHO). At the other end, we consider the strategy that uses cluster heads to handle the maintenance operations, called Cluster-Based With Head Overlay (CWHO). In-between two extremes, we investigate a third possibility, called Clusters with Neighbor Information (CNI). We provide an in-depth and comprehensive study of these strategies under various network conditions and mobility models. Our experimental evaluation shows that the data delivery ratio of CWOHO is at least 7% more than CWHO, under increasing node mobility and number of clusters. However, the reverse is true for the control overhead.

Keywords: Mobile Ad Hoc Network, State Maintenance, Clustering

1. Introduction

Clustering is an effective strategy for tackling the dynamicity and scalability of a large-scale mobile ad hoc network (MANET) [1]. The cluster-based routing protocols [2, 3, 4, 5] are more scalable then flat routing protocols [6, 7], as clustering reduces the size of routing table and also the overhead required to maintain the routing information. Clustering can increase the availability of network information, such as location of the mobile nodes, by replicating information to different nodes in different clusters [8, 9, 10]. When performing broadcast or multicast, clustering allows selective flooding to reduce redundant broadcast messages [11]. Furthermore, clustering facilitates efficient resource management by sharing and reserving resources in a controlled fashion to meet the QoS requirements of applications [3].

Previous research works consider different clustering techniques in ad hoc network, such as using dominating sets [12, 13, 14], distributed clustering [15], beacon-based [16, 17, 18] and location-based [8, 9, 10], mainly focusing on the construction of clusters to handle node mobility or optimizing power/overhead of the head nodes. In this paper, we assume that the network is already clustered and consider different techniques for implementing a maintenance sublayer to handle the dynamic state of the clusters, such as available nodes and data/files, network connectivity, bandwidth, processing capability and others. The idea is to hide the dynamics of the underlying clusters, to improve the performance of cluster-based applications in MANET, Figure-1.

Maintaining state of the clusters involve two primary operations – collection and distribution of information. In the collection phase, nodes collect the state information of its local cluster and in the distribution phase, information is shared with other clusters. The maintenance problem is challenging in MANET because of the mobility of nodes, which can frequently change the state of the clusters and increase the overhead of performing collection and distribution operations. A good maintenance strategy should balance the workload and power consumption of the nodes, incur minimal overhead, and track the changes timely and accurately.

Notice that, for managing any state information (e.g., data/files, bandwidth, processing capability), a maintaining protocol needs to perform the collection and distribution operations. In this paper, without loss of generality, we consider the logical *connectivity* between clusters as the state information. Two clusters are *connected*, if they are adjacent to each other and can directly route messages between themselves, through a border node. We can model the clusters and connections between them as an *overlay*

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