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On the Scope of Backbone Formation in Wireless Ad Hoc Networks

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Abstract

Message efficiency is a prime concern in wireless computing because the nodes are resource constrained, failure prone, and sometimes mobile too. Over the years, the backbone construction has emerged as a powerful approach to achieve message efficiency and handle mobility in ad hoc wireless networks. In the existing literature, most popular techniques for virtual backbone formation are connected dominating set, weakly connected dominating set, cluster based approach, and tree based approach. The article summarizes these popular approaches on virtual backbone construction.

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1. Introduction

Wireless ad hoc network [12] is a temporarily created network without any fixed infrastructure or central control. Any two nodes in wireless network can communicate with each other if they are in the transmission range of each other and such nodes are called neighbors. The nodes that are not within transmission range of each other can communicate with the help of intermediate nodes. Thus, each wireless node works as router too. Therefore, the mobility or failure of a single node may adversely affect the application continuity. In order to mitigate this problem, some 'better' nodes are assigned 'more' responsibility related to routing and computing. These 'better' nodes are called backbone nodes. Any pair of non-neighbor nodes communicates through backbone nodes. The backbone nodes are connected in the form of some structure like tree, ring or any other logical structure. In other words, the set of backbone nodes form a virtual network. With the help of such virtual network route setup and maintenance becomes easy. The virtual backbone plays a very crucial role in the networks. It reduces the routing overhead and increases the convergence speed. In mobile ad hoc network (MANET), virtual backbone is used to handle the node mobility with fewer messages and in less time. In the article, we have included salient works that have proposed methods to deal with the formation of virtual backbone in wireless ad hoc network. Additionally, we have included algorithms that are applicable to construct virtual backbone for mobile ad hoc networks. The cognitive radio network

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(CRN) is a new class of opportunistic networks that enhances spectrum utilization. In the end, we have discussed the scope of backbone construction in opportunistic networks too.

The rest of this paper is organized as follows. Section 2 describes various techniques to construct the virtual backbone for wireless ad hoc network. Section 3 presents the brief description on the formation of virtual backbone for mobile ad hoc network. Section 4 covers the introduction to cognitive radio network and the challenges in creating virtual backbone for it. Section 5 concludes the article.

2. Backbone construction in wireless ad hoc network

Connected dominating set (CDS) is a popular graphical structure to construct virtual backbone in wireless ad hoc networks. It is a set S of vertices, where every vertex in the network either belongs to the set S or adjacent to a vertex in S. A handful number of techniques have been proposed in the literature to compute CDS. Now, we will review some important and interesting algorithms for construction of CDS as well as virtual backbone in wireless ad hoc network.

In [3], authors have focused on computing the CDS for the purpose of virtual backbone formation. The proposed protocol to construct the CDS is based on marking approach. It follows the following steps: (1) All the nodes are initially unmarked. (2) A node is marked, only if at least two of its neighbours are unconnected. (3) All marked nodes are connected to form a CDS. Further we have implemented this WuLi protocol in algorithmic form for better understanding. Assume that G= (V,E) is a representation of wireless ad hoc network. V is a set of vertices and E is a set of edges. NL_i represents neighbour list of node/vertex $i \in V$.

Step 1. $\forall\ i \in V$, node i is unmarked. // all the nodes are initially unmarked.

Step 2. $\forall\ i \in V$

- (a) Find out NL_i //calculation of neighbour list
- (b) Node i sends NL_i to $\forall\ j \in NL_i$ //each node is sharing neighbour list with neighbours.

Step 3. $\forall\ i \in V$ repeat step 4

Step 4. Upon receipt of NL_j by node i from $\forall\ j \in NL_i$ /*node i receives neighbour list from all its neighbours*/

- (a) $\forall\ v \in NL_i$, if v does not exist in NL_i , where $\exists j \in NL_i\ (v \neq j)$
  then node i is marked /* if there exists atleast two unconnected neighbours of node i, node i is marked*/
- (b) $\forall\ v \in NL_i$ and $\forall\ u \in NL_i\ (u \neq v)$,
  If v exists in NL_u then node is not marked. /*if node i's neighbours are connected then node is unmarked */

Step 5. Connect all marked nodes to form CDS.

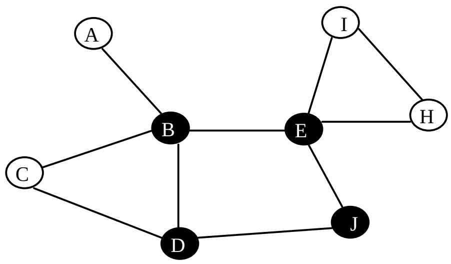

Fig. 1. Construction of CDS.

According to WuLi protocol, CDS is a virtual backbone for wireless ad hoc network. We implement this protocol on graph shown in figure 1. Assume that all nodes are unmarked and V= {A, B, C, D, E, F, H, I}. Neighbour list of each node is computed and given as follows.

NL_A={B}, NL_B={A, C, D, E}, NL_C={B, D}, NL_D= {B, C, F}, NL_E= {B, F, I, H}, NL_F = {D, E}, NL_I= {E, H}, NL_H ={E, I}. Since each node shares its neighbour list to its neighbours. Hence node A receives NL_B and unmarked itself because it has only one neighbour, node B. Node B receives NL_A, NL_C, NL_D, NL_E, node A is searched in NL_C and found that node A does not exists in NL_C, it means node A and node C are unconnected and both are present in neighbour list (NL_B) of node B; node B has two unconnected neighbours, therefore node B is marked. Similarly