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An Algorithmic Approach to Improve Routing Efficiency in Mobile Ad – Hoc Network

Anil Kumar[*1], Savita Shiwani[2]
[*1]SBNITM, Jaipur, India
[2]Suresh Gyan Vihar University, Jaipur, India
er.anilkumar@gmail.com

Abstract

In wireless networks, due to the lack of fixed infrastructure or centralized administration, a Connected Dominating Set (CDS) of the graph representing the network is an ideal candidate which can serve as the virtual backbone of a wireless network. Connected Dominating Set based routing is a promising approach for enhancing the routing efficiency and communication range in case of wireless ad hoc networks. However, finding the Minimal Connected dominating set in an arbitrary graph is a NP-hard problem. Through MCDS, I am proposing an approach through which we will be able to enhance the "Routing Efficiency & Communication Range" of networks by choosing some specific nodes. These very specific nodes will be assumed to be "Dominator" nodes.

In case of wireless networks, the node represents the Workstations and a temporary connection between them is the links which connect any two nodes. This concept can be clearer by the theory of Graph.

Connected Dominating Set (CDS) has been a well known approach for constructing a virtual backbone to alleviate the broadcasting storm in wireless networks.

Keywords: Virtual backbone, Dominating set.

Introduction

Wireless Communication and Wireless Networking are becoming more and more popular now-a-days. A Mobile Ad-hoc network [1] is a collection of wireless nodes communicating with each other in the absence of any fixed infrastructure. An ad-hoc network is totally temporary arrangement without any Centralized Administration. Topology changes from time to time, due to change in situation of each node. Since all nodes are mobile, each node works as a Host as well as a Router. So, Mobile Ad-Hoc Network is self creating, self organizing and self administering.

A Mobile Ad hoc network is a special type of wireless network in which a collection of wireless hosts with wireless network interfaces encompasses of a temporary network, without the aid of any established infrastructure or centralized administration. If two hosts that want to communicate are outside their Wireless Transmission Ranges, they could communicate only if other hosts between them in the Ad hoc network are willing to forward packets for them. A un-weighted graph G = (V,E) is used to represent an Ad hoc network, where V represents a set of Wireless Mobile Hosts and E represents a set of Edges.

Routing Scheme in Ad-hoc networks is more challenging and tedious than traditional routing in terms of Dynamic Network Topology. Routing is an important factor, which plays a vital role to improve the Network Efficiency. All the communication schemes such as due to change in Topology, Multicast Routing Protocol is enabling to cope up with mobility. In multi hop ad-hoc networks, routing becomes more complex because of mobility of both Hosts and Routers.

Some important factors such as Variable Wireless Link Quality, Propagation Path Loss, Fading, Multi-User Interferences, Power Expansion and complexities to the routing protocol design [5]. Main goal of protocol is to achieve maximum performances with minimum cost according to capacity. Performance depends upon Loop Count, Delay Loss Rate, Throughput and Stability. While capacity depends upon a available resources density of network - change of Topology Bandwidth Restriction and rapid change in Network Topology are two factors which differentiate Ad-hoc network

with other network. A desired feature of routing protocol is to provide fast routing without loops.

Minimum Connected Dominating Set (MCDS) Approach

Blind Broadcast [12] in a Mobile Ad hoc network is a common problem. Blind Broadcast in a wireless ad hoc network means any wireless node will rebroadcast all received broadcast messages. One node may receive the same copy of a message from more than one Neighbor. Hence, Unnecessary Overhead is introduced.

A Connected Dominating Set [13, 14] is used to reduce Broadcast Overhead. A common source of overhead in a Mobile Ad hoc network comes from blind broadcasts. Assuming the worst case, nodes in a wireless ad hoc network rebroadcast all received broadcast messages. Nodes may receive multiple copies of the same message from more than one neighbor. Therefore, reducing redundant broadcast messages can reduce channel bandwidth consumption and increase bandwidth efficiency. It is possible to significantly reduce the overhead by using the Minimal Connected Dominating Set (MCDS) [12] approach to reduce the redundancy due to these Blind Broadcasts.

In a simple Graph G = (V, E) where V is the set of Nodes and E is the set of Edges Assume a node set T is subset of V such that for all 'X' in V-T, there exist 'Y' belongs to V, such that edge (x,y) belongs to E [12]. This is the core property for a CDS (Connected Dominating Set). Set T is called a Dominating Set. Set T is called a Connected Dominating Set (CDS) when T forms a Connected Graph. This is the Connectivity Property for a CDS.

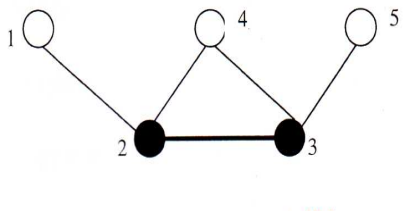

Fig. 1: An example of CDS

Figure 1 gives an example of a CDS. Black Nodes 2 and 3 are connected and cover all nodes in the network. They form a CDS for this graph. Minimal Set of CDS is known as Minimal Connected Dominating Set (MCDS). Since in given example CDS is already minimal, hence MCDS includes node 2 and node 3.

MCDS in Mobile Ad - hoc network is treated as a Virtual Backbone for the whole network. A Virtual Backbone [16,17] Structure in the Ad-hoc network is useful, in order to support Unicast, Multicast, and Fault-Tolerant Routing within the Ad-hoc network. This virtual backbone differs from the wired backbone of cellular network. The hosts in the MCDS maintain local copies of the Global Topology of the network, along with shortest paths between all pairs of nodes.

MCDS Selection Using Articulation Point

To generate routes proactively or On-Demand is extremely costly for energy and resource constrained nodes in a limited bandwidth shared wireless channel. Communication by blind broadcast that induces an intolerable overhead is not a feasible solution. A backbone similar to fixed infrastructure network is required for cost effective communication and maintenance of the route. Similar to the fixed network, only a sub set of the nodes participate in the creation, updation, and maintenance of the backbone, absolving all other nodes of these tasks, conserving resources. It is therefore, proposed to restrict the routing process in Wireless Ad hoc networks thereby, to the formation of a Virtual Backbone. A virtual backbone can reduce the communication overhead, increase the bandwidth efficiency, reduce channel bandwidth consumption, decrease the energy consumption, increase network operation life, and provides better resource management. Thus, virtual backbone optimizes information delivery in a wireless ad hoc network. A Connected Dominating Set (CDS) can be implemented as virtual backbone in wireless ad hoc networks. For an optimal backbone from connected dominating set approach, it must be of minimum size. The heuristics for CDS is divided into two sets. The first set of heuristics strive to find disconnected maximum independent set of nodes and that are joined through Minimum Spanning Tree. The second type of heuristics concentrates on evolving a CDS by growing a small trivial CDS.

A vertex S in a connected graph G (V, E) is an Articulation Point [21] if and only if the deletion of Vertex S together with all edges incident to S disconnects the graph into two or more non-empty components. Where V is set of nodes and E is set of edges.

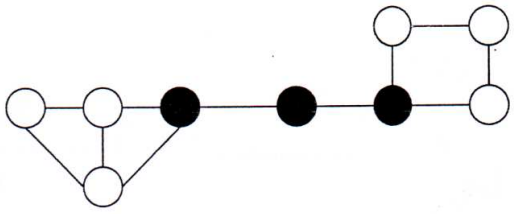

Fig. 2: Articulation Points in a Graph

In Fig. 2, all Black nodes are Articulation Points for this Graph. Removal of Black node creates disconnected components of graph. The presence of articulation points in a connected graph is undeniable feature for Communication Network. The failure of a node that is an articulation point implies that they will always be a part of the MCDS.

With the inclusion of Articulation Points concept, the heuristic starts with Right choice. In our proposed algorithms, the CDS Formation always starts with articulation points.

Concluding Remarks

One benefit of our proposed different algorithms for calculating Connected Dominating set in the Mobile Ad - hoc Networks. Proposed algorithms introduced the implementation of Articulation Point concept into MCDS problem and discussed how to find the MCDS problem using Articulation Points. Analysis shows that inclusion of articulation point concept gives a better solution compared to Heuristic Approach.

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