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A New Routing Protocol for Heterogeneous Mobile Ad Hoc Networks

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Abstract – Each Mobile Ad hoc Network (MANET) consists of some independent system contacting with each other wirelessly. Most of routing protocols work well with this hypothesis, that the network is homogeneous and they are not appropriate for Heterogeneous Mobile Ad hoc Networks (HMANET) and they also lose their efficiency in such networks. Homogeneous Mobile Ad hoc Networks are networks in which all nodes have the same sources and capabilities, and this is in contrast with nature of MANETs because nodes are independent and have different sources, capabilities (such as battery lifetime, bandwidth, transmission range,...) and mobility. In this paper, we improve one of proactive routing protocols named OLSR (Optimized Link State Routing Protocol) so that this protocol becomes appropriate for HMANET and do not lose its capability and scalability. In our method, we suggest an algorithm which uses all existing links (unidirectional, bidirectional) in a network that works within OLSR routing protocol and this causes better use of sources and minimizes MPR (Multipoint Relays) set.

Keywords – *Routing, Mobile Ad hoc Networks (MANET), Heterogeneous MANET (HMANET), Optimized Link State Routing Protocol (OLSR).*

1. Introduction

Transmitting an information package from source to destination is called Routing. Routing algorithms are divided into two groups: centralized, decentralized (based on the method of gathering and processing communication network infrastructure). In centralized algorithms, each router has complete information about communication network infrastructure, such algorithms are called, Link State routing algorithm (LS) such as OSPE (Open Shortest Path First) routing protocol, [1, 2]. In decentralized algorithms, routers have no complete information about communication network infrastructure and only can obtain the cost of communication with neighbor routers, which are called distance vector algorithms such as

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Routing Information Protocol (RIP) [3]. Mobile ad hoc networks consist of a group of wireless mobile nodes which have no special structure; therefore each node can be a router or an end user so routing is one of the main challenges for these networks. Many routing protocols have been introduced, but most of them are supposed to be homogenous networks and lose their efficiency in heterogeneous networks. Generally, routing protocols are divided into three groups [4]:

- Proactive routing protocols (Table driven)
- Reactive routing protocols (On-demand)
- Hybrid routing protocols

In proactive routing protocols, each node has up to date route to other nodes and this method has too much overhead because of scattering controlling packets, but it has a better delivery rate in comparison with other methods. For every time that a node decides to send a packet to a destination node, there is a route in its routing table to it [5, 6, 7]. In sending a packet from a source to a destination in reactive routing protocols, at first the protocol finds the route and then uses it. Since the found route is based on the needs, this method has lower overhead and has a lower delivery rate [8, 9, 10, 11]. Hybrid routing protocols use a combination of these two protocols. They have a ready route for some nodes and they have to find a route for other nodes, then transmission will be done [12, 13, 14]. Most of the introduced routing protocols, is assumed as homogeneous networks, and this is in contradiction with the main nature of mobile ad hoc networks, because all nodes are independent and they have different sources and capabilities (transmission range, battery life, bandwidth,…). Such networks are called Heterogeneous MANETs (HMANETs). Therefore, most of the routing protocols do not use resources and capabilities of nodes in an optimized and appropriate manner and this subject is of more importance when the network becomes larger. Whereas nodes are able to communicate with each other, when resources and other capabilities are heterogeneous, this communication in immediate networks will make some troubles. One of the criteria in testing efficiency of routing protocol is scalability. Scalability means that when the network becomes larger, increased number of nodes and other changes, it does not lose its efficiency and be able to adapt to conditions. HMANETs have more scalability than homogeneous MANETs [15].

The remainder of this article is organized as follows. In section 2, we review OLSR routing protocol and in section 3, the proposed method is introduced. In section 4, we compare OLSR with proposed method by an example and finally, we conclude the paper in conclusion section.

2. Related Works

L. Villasenor-Gonzal et al. [16] have introduced HOLSR which is an extended version of OLSR [17]. The process of this protocol is as follows. Components of the network are divided into logical levels based on the number of their wireless interface and capabilities. In this division, nodes with lower capability and a wireless interface work in level one. Nodes with medium capability and at most two wireless interfaces can work on level one and level two. Nodes with higher capability and at most three wireless interfaces can work at levels one, two and three. Each level consists of multiple clusters and in each cluster the node that has the most capability to communicate, become cluster head automatically. In each protocol, cluster heads work as gates. In other words, nodes in a cluster are able to communicate based on their routing table. If a node wants to send a packet to a node that is not in the same cluster, firstly delivers it to its cluster head and the packet transfers between the cluster heads until being received by a cluster head that covers the destination node, so it has a route to the destination node and sends the packet to the destination node through it. Lee et al. [18] have introduced hybrid landmark routing (HLANMAR) protocol, which is an extended version of LANMAR [19]. This protocol considers a group of nodes moving together as a logical subset and chooses a landmark node for each group or subset. In this method, routing for nodes in a group is proactive and for those that do not belong to a group or subset is reactive and a landmark node is responsible for communication between groups. Maekawa et al. [21] have introduced Ant-based routing protocol, which is an extended version of AntHocNet [20]. The main idea of Ant Colony Optimization (ACO) algorithm is to get routing information by sending control packets, which are called ants. Each node, sends independently, several ants for finding a route to the destination. Each ant comes back from the found route so that interface nodes up to date their information. If, in return the ant faces to a unidirectional link, it will change the route by broadcasting itself until finding a route to the destination. Safa et al. [22] have introduced HAODV, which is an extended version of AODV [10]. In this protocol, nodes use different technologies for communicating (Bluetooth, WIFI or both of them); however, in AODV, it is supposed that all nodes use WIFI technology. It is remarkable that route finding process in both protocols (AODV, HAODV) is the same.

3. OLSR (Optimized Link State Routing Protocol)

The method of the Link State routing protocol is as follows: Each node broadcasts its routing table in a periodic manner or when a change is occurred and all of the nodes that received this information has to retransmit it unchangeability to other neighbors except the node that has sent the information (Figure one). Because of spreading the controlling information, this method has much overhead. To solve this problem in 2001 Muhlethale, Clausen [17] proposed OLSR routing protocol, which is a link state routing protocol that work in a proactive manner and is appropriate for big and dense networks. In this method each node, chooses independently, a subset of its neighbor nodes (Nodes that are one hop far from it) and only those nodes are allowed to retransmit its packets. Chosen nodes are called Multipoint Relays (MPR). Other nodes only read and process received packets, but do not retransmit them (Figure 2). Each node selects its multipoint relay set among its one hop symmetric neighbors (A neighbor is symmetric when the connection with the node is bidirectional) in such a manner that the set covers all nodes that are 2 hops far away and the connection between these nodes has to be bidirectional (Figure 3). Nodes have an MPR Selector table, which recognizes those nodes that have chosen it as MPR. It is a remarkable MPR set of a node is unsteady. The lower number of MPR nodes in one node, the more optimal and efficiently the algorithm. In this method, nodes by topology control messages (TC), broadcast periodically its MPR selector table and each node uses the new received information to up to date its routing table. Each route consists of several MPR nodes, from source to destination. Periodically, each node broadcasts hello messages. This message consists of information about its neighbors and their links' status (Unidirectional or Bidirectional). Those neighbors who are one hop far from it will receive this message.

Consequently, each node gets information about the status of its neighbors and the node covered by them so the node can figure out which node is two hops far from it and by this information each node chooses it MPR's. There for routing table of node consists of following items:

- A list of neighbors that is one hop far from it.
- The nodes covered by each of the neighbors, individually.
- The status of links that can be unidirectional, bidirectional or MPR.

MPR status means that the link is bidirectional (the neighbor is a symmetric neighbor) and also means that the node is chosen as an MPR.

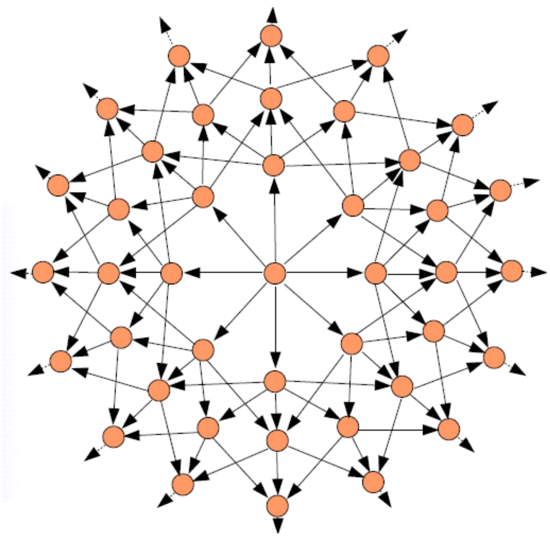


Figure1: Usual Broadcasting

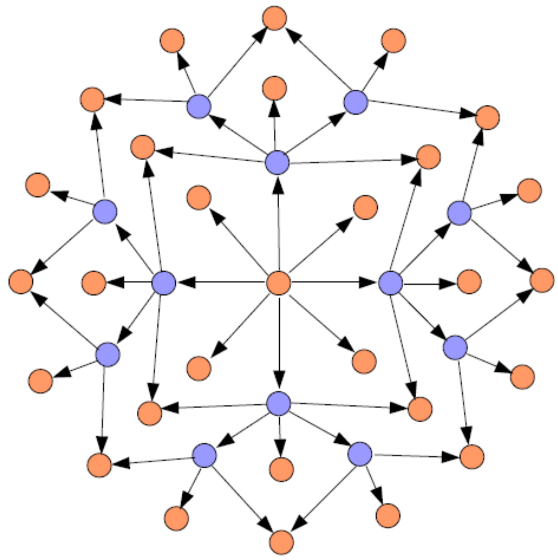


Figure2: Broadcasting in OLSR method

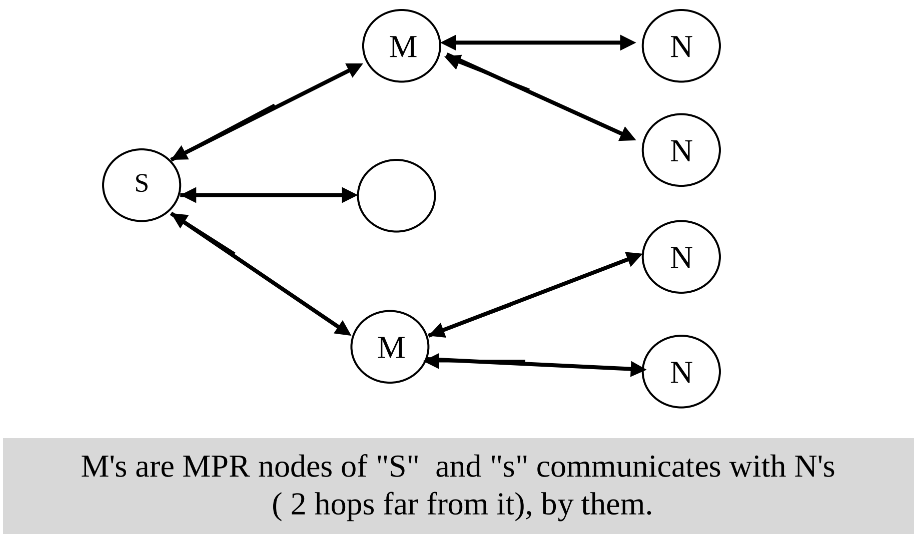


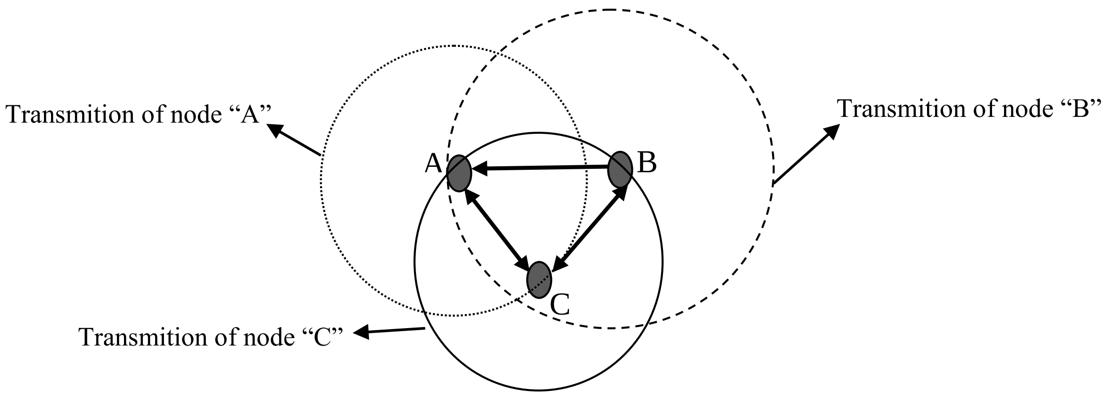
Figure3: Selection of MPR nodes in OLSR.

In this protocol, nodes by using two control messages (TC, Hello) recognizes topology of the network and up to date its routing table. When it needs to send a packet to a destination, it will use the existing route in the table. As seen, this protocol has lower overhead.

4. Proposed Method

As said in OLSR, nodes choose its MPR only among its symmetric neighbors and do not use unidirectional links (Figure 4). As illustrated, the node B has more transition range than the node A and node B covers node A but not vice versa, therefore their relation is unidirectional in this way the node A receives the message of the node B but not vice versa. As shown in figure 4 the link BA is unidirectional but that of BC and AC are bidirectional. Our main idea in this paper is to use all the links (Unidirectional, Bidirectional) since a node may be in the range of another node, for example: Although the node A is in the range of nod B (Figure 4) and covers many nodes, but because of being asymmetric it will not be chosen as MPR node of node B but by choosing the node A as MPR of the node B, the set of MPR of the node B became minimized and this causes:

a) More efficiency
b) Decreased the number of sent broadcasted packets.
c) Less receiving duplicate messages by nodes.
d) Increased scalability.



In unidirectional BA link, the node B is upstream node and the node A is downstream node.

Figure 4: A sample of unidirectional and bidirectional links

Therefore, losing one connection this method can adopt itself with new situations and keep its efficiency. Obviously, in OLSR method, MPR set is not minimized, but in proposed method, it is minimized because MPR nodes are selected among all one hop neighbor nodes (Symmetric, Asymmetric). The proposed method is as follows:

Nodes which are in the range of other nodes and their communication is unidirectional such as the node A that is in the range of the node B, sends a message by other nodes such as the node C to the node B and in this way it announces its existence to node B till node A has the chance to be selected by node B as MPR. Node A is a response neighbor of node B (Figure 4).

5. Comparing OLSR and Proposed Method

In this section, we describe the method of selecting MPR in OLSR and the proposed method by an example. Consider figure 5. In this example, it is supposed that node B has to select its MPR set. As illustrated in figure 5 the node B has two symmetric neighbors (Nodes C, D) and has one response neighbor (Node A). The node C covers nodes F and G, the node D covers the nodes F and E, the node A covers the nodes F, E and G therefore nodes C and D are of degree 2 and node A is of degree 3. In OLSR the MPR set of the node B is nodes C and node D but in our method only node A will be selected as MPR of node B. It is obvious that MPR set has become minimized and the number of received duplicated packets by node F which is in the range of nodes A, D, C has decreased because only node A sends packets of node B for it not nodes C and D. The above explanation is summarized in tables 1 and 2.

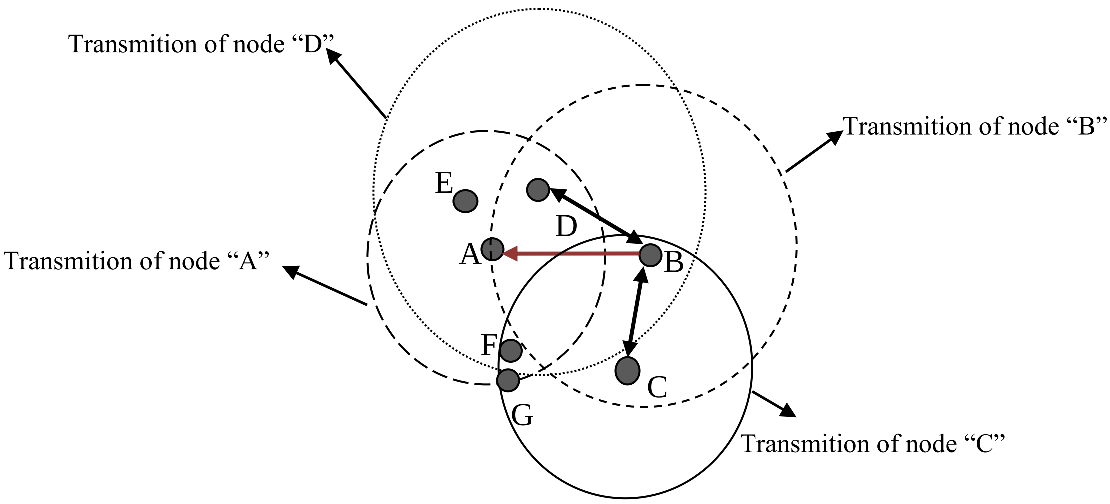


Figure 5: One hop and two hop neighbors and response neighbors of node" B"

As you see in figure 6, the selected route from the source node "X" to the destination node"P" by HEOLSR is X-Y-Q-B-E-P that is shorter than the selected route by OLSR (X-Z-C-A-B-E-P).

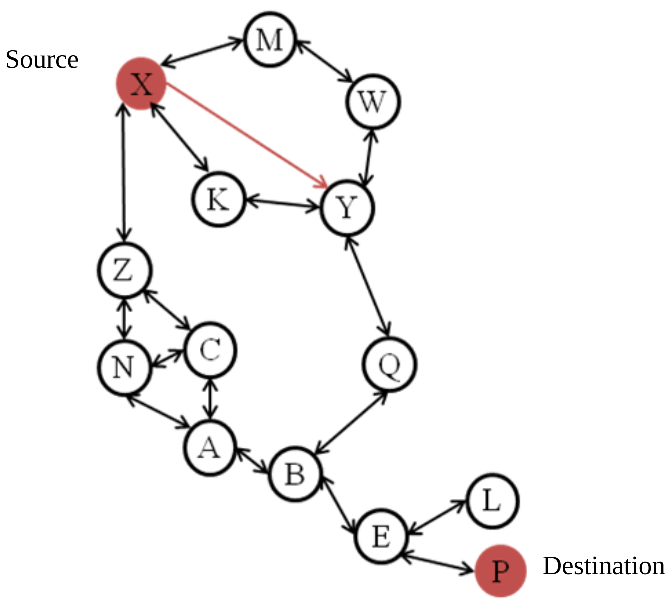


Figure 6: Topology of a heterogeneous MANET

Table 1: Selected MPR's by node B in OLSR

Node	One hop neighbors	Two hop neighbors	MPR nodes
B	C, D	F, E, G	D, C

Table 2: Selected MPR's by node B in proposed method

Node	Response neighbors	One hop neighbors	Two hop neighbors	MPR nodes
B	A	C, D	F, E, G	A

6. Conclusion

Since in MANET's, nodes are completely independent (Each node has its own sources and capabilities) and since routing is an important challenge in networks, using routing protocols that are able to use all capabilities of the node is necessary because it increases efficiency and network life. Using our method causes all links and neighbor nodes to be used consequently MPR set is minimized so the efficiency of network improves and sending broadcasted packets decreases therefore less duplicated messages will be received by nodes. One of the benefits of our method is to improve scalability. Finally, this new method is appropriate for using in both homogeneous and heterogeneous mobile Ad hoc networks. This method not only does not lose its efficiency in homogeneous MANET's but also works efficiently in heterogeneous MANET's.

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