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A study of the effect of different topology parameters on the routing overhead for Ad Hoc networks

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Abstract: *Because of the dynamic nature of the topology in Ad hoc networks, a new type of routing protocols has been developed. These Ad hoc routing protocols react faster than the classic routing protocols to topology changes. When a path between tow nodes is broken, the routing protocol finds an alternative path to reconnect the two nodes. Random topology changes and other topology parameters can highly affect the volume of routing overhead. For this reason, the routing protocols for Ad hoc networks use different methods to reduce routing over head. In this paper we present a new routing technique and we study its effect on routing overhead by running multiple simulations.*
Keywords: *Ad hoc network; routing protocol; topology parameters; routing overhead*

I. INTRODUCTION

By the manner that the protocols use to build a path between two nodes, the routing protocols for Ad hoc networks can be categorized as proactive, reactive or hybrid. Proactive protocols create a routing table that contains a path to all the possible destinations in the network. This approach reduces transmission delay since all the paths are already defined but increases the quantity of routing overhead. The reactive approach constructs a path between two nodes only when needed. Even if this method reduces the routing overhead generated by the nodes significantly, the reactive approach increases the transmission delay. The third type which is the hybrid protocols combines the reactive approach and the proactive approach. The proactive approach is used in the close neighborhood only and the reactive approach is used when there is no path leading to the destination. This makes the hybrid protocols benefit from the advantages of the proactive and the reactive approach at the same time. The inconvenient of the hybrid protocols is the fact that transmission delay can be high when the destinations is not in the close neighborhood (even if the proactive approach is used to reduce it) and the paths that result from the path discovery process are most likely not the shortest ones.

Generally, an Ad hoc network is used to provide and maintain a connection between all the components of the network at all time. For example, in a military operation all the participant need to maintain contact at all time. This is why we believe that the proactive approach is more suitable of such applications. Unlike the reactive approach that build path only on demand, the proactive approach maintain the paths between all the nodes. On the other hand, to maintain the routing table up to date the nodes exchange their routing messages. This periodic exchange of routing information's increases the routing overhead. To reduce the routing overhead, the proactive protocols use different methods in order to adapt to the different parameters of the network (network size, nodes mobility, nodes transmission range …etc). In this paper we present the mechanism used in our own routing protocol and we run some simulation in order to verify its reaction to the changes in network parameters. The protocol we present in this paper is called ERBOR (Effective Routing Based on Overhead Reduction). In Section I we discuss the different strategies used by proactive routing protocols to reduce the routing overhead. Section II we present our protocol and its main techniques to reduce routing overhead. Section III contains multiple simulations that we executed in order to study the effect of different network parameters on the routing overhead generated by our protocol. Section IV concludes our paper.

II. ROUTING OVERHEAD REDUCTION STRATEGIES

To reduce routing overhead, many techniques has been included in the proactive routing protocols. In FSR [1] (Fisheye State Routing) the nodes broadcast the routing entries describing their close neighbors more often than the node far away. This technique reduces the routing overhead efficiently. In [2], DREAM (Distance Routing Effect Algorithm of Mobility) uses the nodes geographic coordinates in order to reduce the routing overhead. A similar mechanism to the one used in FSR is applied so the information's about the nodes far away is rarely transmitted. This protocol also uses the relative speed of the node in order to define the frequency that the node broadcast its routing information with. This way, the nodes that are moving fast broadcast their routing information's more often than the nodes moving slowly.

A different approach is used in OLSR [3] (Optimized Link Stat Routing). In this protocol, the nodes selects only a subset of it neighbors that are in charge of rebroadcasting its routing information. The subset of neighbors selected by the node is called MPR's (Multi Point Relay). These neighbors selected as MPR's of a node must be enough to reach all the neighbors two hops away. Any neighbor that is considered as redundant in path construction doesn't belong to in the MPR list (a neighbor that can be reached by another path). This method reduces the number of links broadcasted on the network. Instead of broadcasting instantly a new routing information every time a topology change is detected, In GSR [4] (Global State Routing) protocol the nodes exchange routing information only periodically. This method is well adapted to nodes mobility. Another approach is used in DSDV [5] (Destination Sequence Distance Vector) where two types of routing messages exist, Full dump (contains the entire routing table) and Incremental update. The nodes send a Full dump when it detects an important topology change. This reduces the size of the Incremental update sent after a Full dump message.

III. ERBOR (EFFECTIVE ROUTING BASED ON OVERHEAD REDUCTION)

In the purpose of building a new proactive routing protocol, we used some techniques from different protocols. The idea of our protocol is to reduce the full routing table exchange to the minimum in order to reduce routing overhead. Also, we use a similar technique to the MPR selection method in order to reduce the complexity of routing tables update and the volume of traffic overhead at the same time. Instead of processing all the routing messages generated by neighbors, each node in our protocol process only the routing messages coming from its MPR nodes.

Different techniques are used to detect the changes in the MPR set. Instead of broadcasting periodically the entire routing table to select the MPR set, the nodes detect the MPR set by the use of routing update only which is smaller than a full routing table and easier to process. If a neighbor can't be reached by any existing MPR node, than this neighbor is a new MPR. In order to actively reduce the MPR set to the minimum. If two MPR nodes of the same node become MPRs to each other, one of the two MPRs nodes is deleted from the MPR ensemble. This technique reduces efficiently the routing overhead and the complexity of routing table update at the same time. Unlike OLSR where the node process all the routing information's broadcasted by its neighbors but rebroadcast only the routing information coming from its MPRs selectors (nodes that selected this node as an MPR), in our protocol the node process only the routing information coming from its MPR selection. This reduces the complexity of routing information treatment. When a routing message is received from a neighbor that's not selected as MPR, the node verifies if there is an existent path to this neighbor. If there is a path it means that this neighbor is redundant in path calculation and therefore this node is not included in the MPR list. If not this neighbor becomes a new MPR. In order to reduce the routing overhead even more, a node broadcast its full routing table only if a new MPR is detected. The combination of these methods reduces the routing overhead and the complexity of routing information treatment.

IV. SIMULATION

Because of the periodic exchange of routing messages between nodes, the changes in the different parameters of the network can affect the amount of routing overhead generated by the nodes. For example, the increase network size increases the routing messages size and the traffic overhead quantity. Other factors that can affect the traffic overhead are the random movements of nodes and nodes transmission range. In this paper we run multiple tests to define the effect of some network parameters on our protocol ERBOR. To measure the routing overhead generated by ERBOR, we implemented a network simulator in Java that's able to create random network topologies and measure the routing overhead generated by the nodes at each instant.

A. The effect of random topology changes on routing overhead

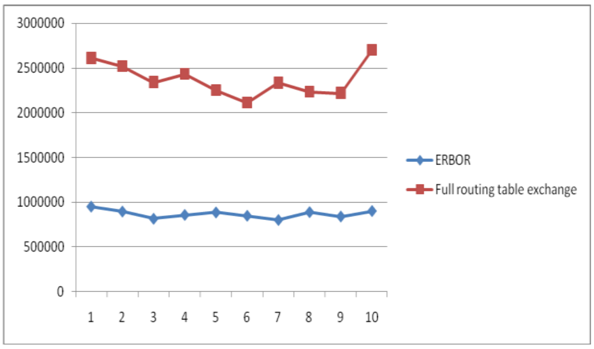

Figure 1The effect of random topology changes on routing overhead

For our first simulations we study the effect of random topology changes on the routing overhead generated by ERBOR. The chart in red represents the traffic overhead generated by the network when the nodes exchange the entire routing table and the chart in blue represents the traffic overhead generated when ERBOR is applied. The traffic overhead in our simulations is measured by counting the number of entries contained in the routing messages.

In order to identify the effect of random topology changes on the quantity of routing information, we ran many simulations with random movement scenario. All the nodes have the same speed and in each simulation 150 nodes are created with 150 units (pixels) of transmission range. After that, the simulators execute a random movement scenario. Once we observe that the protocol has completely converged, we have stoped the simulation and have recorded the traffic overhead generated by the two techniques (full routing table exchange and the ERBOR method of routing information exchange).

Figure 1 represents the results recorded from ten consecutive simulations. The results show that the random topology changes don't have a significant effect on the traffic overhead generated by ERBOR. On the other hand, it's noticeable that the traffic overhead generated by the full routing table exchange is much more affected by the random topology changes. These results can be explained by the fact that ERBOR use the MPR technique. This technique uses only a subset of the neighbors list to propagate routing information's. This way, the topology changes (a neighbor move away or a new neighbor is detected) are not rebroadcasted by all the neighbors which reduces the nodes movement effect on the routing overhead.

B. The effect of network size on routing overhead

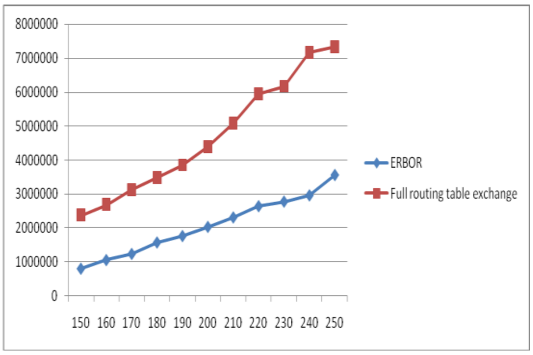

Figure 2 The effect of network size on routing overhead

In the second experiment, we study the effect of the network size on the routing overhead. We execute multiple simulations where we start at first with a network that contains 150 nodes and after each simulation we increase the network size by 10 new nodes.

One of the most commune problems encountered in proactive routing protocols is the exponential increase of routing overhead when the network size is increased. In ERBOR, we tried to reduce the effect of the network size by the method that the protocol uses to exchange routing messages. With the increase of network size, the size of the routing table and the complexity of routing table update operations increases as well. ERBOR minimizes the exchange of routing tables and thus minimizes the quantity of routing overhead. A node broadcast its routing table only if at least a new MPR node is detected. This explains why the quantity of routing overhead generated by ERBOR is smaller than the routing overhead generated by the network when the full routing table is sent. Thus, the results in Figure 2 show that even if the routing overhead generated by ERBOR increases when the network size is increased; the routing information exchange method reduces the traffic overhead. On the other hand, the exchange of the full routing table increases substantially the traffic overhead.

C. The effect of nodes transmission range on the routing overhead

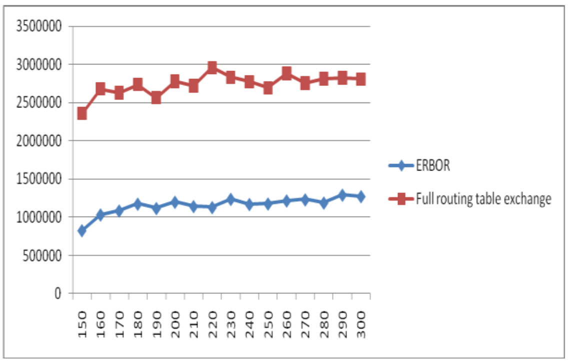

Figure 3 The effect of nodes transmission range on the routing overhead

Another parameter that can affect the traffic overhead is the nodes transmission range. In Figure 3, we execute a series of simulations where we increase the transmission range after each simulation. At first we start with 150 nodes network where each node have a transmission range of 150 units (pixels). After each simulation the transmission range is increased by 10 units until the transmission range reaches 300 units in all the nodes. The simulations show that the increase of nodes transmission range increases only slightly the quantity of traffic overhead generated by ERBOR. The increase of transmission range of a node imply that the number of neighbors detected by each nodes increases. Thus, the number of links and the traffic overhead increases. With the MPR selection technique, the nodes broadcast only the links with their MPR and thus the traffic overhead generated by ERBOR is reduced. This explains the results presented in Figure 3.

D. The effect of misbehaving nodes on routing overhead

The misbehaving nodes are the nodes that do not participate on the propagation of the routing information's of their neighbors. This kind of nodes overhears the routing messages of their neighbors but do not contribute in routing functions. Consequently, the misbehaving nodes decrease the network performance. In order to identify the effect of the misbehaving nodes on ERBOR, we conduct many simulations where we add misbehaving nodes to the network. At first, the network does not contain any misbehaving nodes. After each simulation we add 10 new misbehaving nodes.

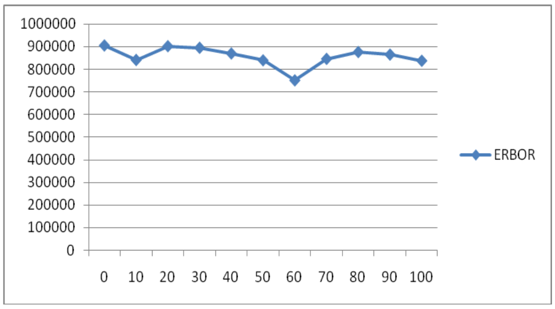

Figure 4 The effect of misbehaving nodes on routing overhead

A node is considered as a misbehaving node if it doesn't broadcast routing information and use its neighbors to forward its traffic. Figure 4 show that the existence of misbehaving nodes doesn't influence the routing functions of ERBOR. Since the misbehaving nodes don't generate any routing information's, they are not selected as MPR. Thus the misbehaving nodes are not used to construct paths between nodes. This explains why the increase of misbehaving nodes up to 100 nodes doesn't influence the performance of ERBOR.

V. CONCLUSION

Due to the periodic exchange of routing messages, the use of a proactive protocol generates an important amount of routing overhead. Most of the traditional proactive protocols exchange the entire routing table in the purpose of updating the routing table of the neighbor. This exchange of the total routing table is the main reason for the increase of routing overhead especially when the network size is increased. Unlike other proactive protocols, ERBOR use a method to minimize the full routing table exchange and thus minimizes the routing overhead when the network size is increased. Additionally, ERBOR uses the MPR technique to reduce the effect of network density on routing overhead. In this paper we present a brief presentation of ERBOR and various topology parameters effect on the routing overhead generated by ERBOR. In future work we will try to include other techniques in order to improve our protocol performances.

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