New Probabilistic-Based Broadcasting Algorithm for Mobile Ad Hoc Networks

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Abstract- **Mobile Ad-hoc Networks (MANETs) have a lot of features, like the autonomous terminal that means each node can function as both host and router. Also, the operations on a MANET are distributed because of the absence of infrastructure and central control of the network. The topology of such network changes dynamically because of the mobility of the nodes. Nodes use Multi-hop routing to guarantee the delivery of messages. A MANET suffers from a set of problems. Most of them arise from the nature of the network itself, since it use wireless communication which is already suffer from the high bit error rate and hence the data exchanged through MANET is more likely to interference, fading, and subjected to noise. In this paper, a new scheme for reactive routing protocols is proposed to decrease the effects of the broadcast storm problem and to discover a more stable route to maximize the throughput of the network and minimize the average delay and the routing overhead.**

Keywords- MANET; Probabilistic-Based; AODV; NPBA.

I. Introduction

Mobile Ad Hoc Networks (MANETs) are networks of mobile nodes that are connected through Multi-hop wireless links without any infrastructure. MANETs received more attention and became one of the significant areas in network world, because of the wide spread of new technologies such as laptops, and mobile phones [1][9]. MANETs are simply built without the need of any infrastructure, it consists of a number of nodes distributed over a geographical area that dynamically change their locations, they are rapidly deployed, self configured and the nodes are connected through wireless links. Due to the nodes mobility, the topology of such networks is rapidly changes [2][10]. MANETs could be stand alone network or connected to external networks (e.g., Internet).

Ad Hoc network has special characteristics such as highly dynamic environment that make the conventional routing protocols not appropriate choice for these networks. The routing process is one of the most challenging aspects in MANET because of its limited resources, distributed operations, dynamic features and instable wireless links. It needs a routing process that constructs and maintains up-to-date routes with minimum overhead and resources consumption [3][7]. The remainder of this paper is organized as follows: Section 2 reviews broadcast in MANETs. In Section 3, we present our proposed protocol. Then in Section 4, we analyze the broadcast based probabilistic scheme with different system parameters. Section 5 accommodates the simulation environment and analyze of our results, whereas Section 6 concludes this study.

II. Related Work

Flooding [11] is the simplest static routing protocol. It does not need any information about the network topology to deliver packets from the source to the destination. When a node wants to send a packet, it transmits this packet to all its neighbors. Then each node that receives this packet for the first time retransmits it to all neighbors except the neighbor from which it was received. This process is continued until the packet reaches all nodes in the network. Each packet has a unique identifier that consists of the source address, a special sequence number used to prevent sending duplicate packets from the same node, and the destination address [12]. The main disadvantage of flooding is the consumption of the network resources because of the high traffic load it generates. On the other hand, it ensures that the packet reaches to the desired destination and gives a high packet delivery ratio. Such routing protocol is still used as a building block for other enhanced protocols, such as DSR [2], and AODV [12].

Distance Vector (DV) routing algorithms [8] are based on Bellman-Ford formula. Its concern is determining the cost to any node in the network. Each node maintains its routing table which contains information about best routes to every node in the network [11]. Different metrics used to calculate the cost between nodes, such as hop count, queue length, and delay. Nodes flood the cost information to neighbors periodically to update their routing tables. Then each neighbor uses this information to recalculate the costs by applying Bellman-Ford formula and comparing it with its local routes to choose the next hop with minimum cost to each destination. The process is repeated every time new distance vector is received from any of the neighbors that cause a change in the node distance vector. The slow convergence of the routing information is the major drawback of DV algorithms [4].

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In the Link State (LS) algorithm, each node has a complete view of all links in the network. A shortest path algorithm is used to determine the best path or route. The best route then is selected based on some metrics like link speed, number of hops, or traffic congestion. Upon topology change, a notification message is flooded to the whole network and each node updates its links state with the new information. The efficiency of LS algorithms is decreased when the size of the network is increased. LS has a highly space complexity because each node stores information for all network elements.

III. NEW PROBABILISTIC-BASED BROADCASTING ALGORITHM

The New Probabilistic-Based Broadcasting Algorithm (NPBA) is an on-demand, broadcast-based; Ad Hoc route discovery protocol that is designed for MANETs. The main goal of this scheme is to minimize redundant broadcasts, and to increase the overall routing performance.
NPBA solves the problem of probabilistic based protocol in sparse networks, where, in such networks nodes do not receive all broadcasts unless probability parameter is high. When probability is 1, this scheme is identical to flooding. So, NPBA adjusts the sending probability of broadcast packet according to certain parameters such as, network density.

IV. DESIGN OF NPBA

NPBA aims to find the best route with lowest cost while preserving network resources. NPBA modifies the route discovery phase specifically the propagation of RREQ packets of the original reactive protocols. Other phases are the same as the original ones. To implement this scheme, a list of neighbors is required to keep track of the current neighbors of the node.
Depending on the network topology, each node in the network is assigned a probability to rebroadcast the upcoming messages. When source node receives a broadcast message, it runs a broadcast procedure to decide whether to continue the broadcast process or to drop it.
According to network topology, network is divided into dense and sparse areas. In dense area, nodes that are located in such area have a low sending probability to incoming broadcast messages. That is clearly minimizes the number of rebroadcast messages. This minimizes the opportunity to reach new sources in the network. But according to this scheme, nodes in dens area check neighbors periodically for any changes of neighborhoods information to ensure that the message is delivered correctly. This can be achieved by adjusting the sending probability.

In Spars area, nodes that are located in such area have high sending probability to incoming broadcast messages. However, if the nodes sense the possibility to reach more nodes it adjusts the sending probability.

The propose algorithm is outlined in figure 1. NPBA consist 5 steps as follows: in step1 and periodically, each node broadcasts a HELLO message containing its address and list of neighbors. In step 2 and upon receiving the HELLO message, a node updates its routing tables and list of neighbors. At any time, the list of neighbor for a particular recipient (*Y*) will contain the addresses of all (*Y*'s) 1-hop neighbors. Then source nodes will run a small procedure for comparing list of neighbors to adjust the forwarding status of the node. After that, in step 3 and 4, each node now adjust its sending probability according to the result of step 2.

When a source node *S* wishes to communicate with a destination *D*, and there is no known route to this destination, it prepares a RREQ message.
Upon receiving the RREQ message in step 5, nodes will propagate the RREQ according to their probability values, where nodes that in their forwarding status will have higher opportunity to propagate the upcoming messages.

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Algorithm:  New Probabilistic-Based Broadcasting Algorithm
  Input:    Ad Hoc network with n nodes
  Output:   route between nodes with minimum cost
    1.  Periodically, every HELLO-INTERVAL broadcast
        a HELLO message, which is already attached
        with list of friend.
    2.  On Receiving a HELLO message:
          1.  Update list of neighbor, so that it will contain
              1-hop neighbor address for all neighbors.
          2.  Compare lists of neighbors, to find new
              destinations.
          3.  Update forwarding status
                If there are new destination could be
                reached
                    Forwarding status = true;
                Else
                    Forwarding status = false;
    3.  Determine the probability of sending according to
        network topology, where dense area has low
        probability, and sparse area has high probability.
    4.  Check Forwarding status with the probability and
        adjust sending probability according to neighbor's
        information.
    5.  Upon receiving an RREQ message, the following
        actions take place:
                If the recipient node is the destination
                  Done
```

Figure 1. An outline of the new probabilistic-based algorithm

V. PERFORMANCE EVALUATION

Simulation experiments are carried out on T6400-2 GHz computer with Intel Core 2 Duo processor, and 4 GB RAM. The operating system is Fedora 10. Network Simulator (NS) version 2.29 was used [13].

NS is discrete even simulator targeted at networking research, it provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless networks, it is heavily used in Ad Hoc networking, it is widely used in a academia due to its open source model.

NS supports many protocols for wireless network such AODV, DSR, and others. The proposed scheme is compared with AODV. AODV [6] was chosen due to the high delivery ratio it scores and low overhead comparing to other routing protocols.

Each run for the simulation lasts for 900 seconds, each simulation scenario within same experiment is repeated 30 times, and their average value is taken to increase accuracy. To study the effects of network density, we used 50, 75, 100, and 125 nodes that are randomly distributed in 600 X 600 m^2 simulation area. And for deep measurement and judgment of our scheme we try different node speeds (5, 10, and 20 m/s). Also different pause times were used (0, 2, and 4 seconds).

The simulations conducted have revealed that a typical value for a sparse region in a network size of 50 nodes contains Ns =4 nodes while a medium region contains Na=16 nodes and a dense region contains Nd =30 nodes. As a consequence, there are, on average, 16 rebroadcasts in highly adjusted probabilistic flooding when the rebroadcast probability, for example, is set at p_1=0.7, p_2=0.35 and $p3$=0.25, respectively.

To study the performance of NPBA and compare it against AODV, two different types of simulation scenarios are conducted:

- **Density Scenarios**: is to study the effect of change in node density on the performance metrics for different protocols.
- **Mobility Scenarios**: is done by varying the maximum speed of the nodes to see how it affects the behaviors of the protocols in terms of some measured metrics.

Our first scenario is to experiment 50, 75,100, and 125 nodes, with speed =5m/s, packet rate equal to 4 packets/second, and pause time= 0.

The simulation results presented in Figures 2, 3, 4, and 5 illustrates the routing packets, packet delivery ratio, normalized load, and average-end-to-end delay.

From Figure 2, it is clear that our protocols achieve major enhancement in terms of reducing the routing overhead for all speed values. This is due to the fact that our protocol tends to control flooding by selecting only a subset of nodes to retransmit packets. This reduction of retransmission saves many control packets from being sent, and this reduces the overall routing overhead. Figure 3 shows also that as the number of nodes increases, the overhead encountered by AODV increases as well. This is because the large number of nodes, the more control packets need in order to manage the whole networks. For small number of nodes, NPBA outperform AODV at most about 32.57 %. The enhancement becomes less significant when number of nodes is large, which reaches about 14%.

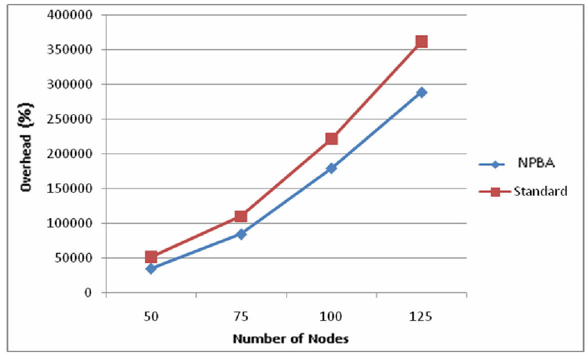

Figure 2. Overhead vs. Number of nodes, with speed =5

The overhead reduction achieved in Figure 2 is reflected positively in the network normalized load as can be seen in Figure 2. For low density networks, the performance of AODV is close to that of NPBA. However, for high density networks, NPBA outperform AODV, but in general as network density increased, the normalize load also increased, due to the huge number of control packets need to be exchanged, and the contention and collisions of these packets.

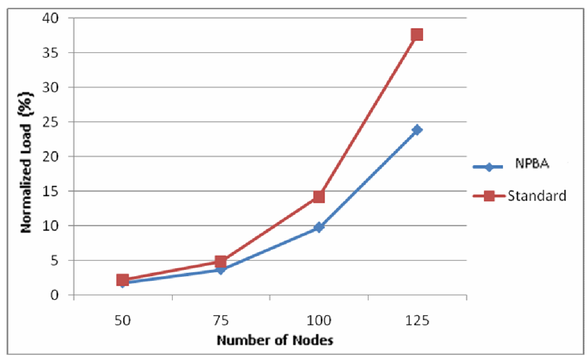

Figure 3. Normalized load vs. Number of nodes, with speed =5

Figure 4 displays the packet delivery ratio for the two protocols and shows the superiority of our prtocol for all numbers of node. This is an expected result since the network overhead decreased and hence number of collisions is decreased, which maximize the chance of delivering packets to its destination.

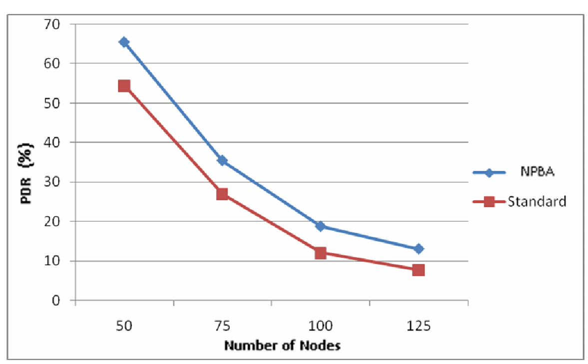

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Figure 4. Packet delivery ratio vs. Number of nodes, with speed =5

Figure 5 depicts the average end-to-end delay achieved by our protocol in comparison with that achieved by AODV. As the Figure shows clearly, our protocol outperforms AODV, which is expected as the end-to-end delay metric includes delays caused by route discovery, queuing and retransmissions at the MAC level. Due to the fact that the routing overhead of our protocol is low and minimized, the packets are no longer needed for a long period of time, in addition, since the number of rebroadcasts is reduced, this will reduce the average end-to-end delay.

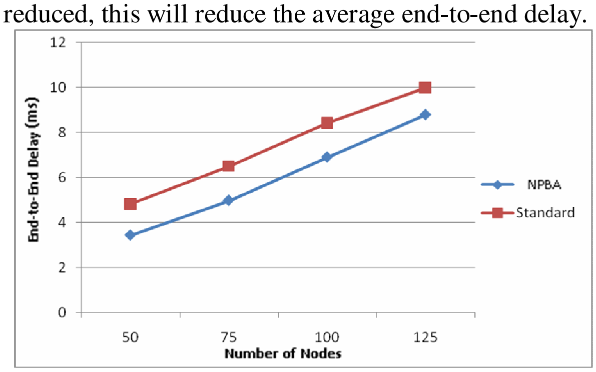

Figure 5. End-to-End Delay vs. Number of nodes, with speed =5

The simulation results presented in Figures, 6and 7 illustrates the routing packets, packet delivery ratio, normalized load, and average-end-to-end delay.

Figure 6 shows that with increasing number of nodes, the overhead of AODV result from number of routing packets increases significantly. It is obviously that NPBA outperforms AODV moderately in all number of nodes with average of enhancement equal to 25.94%.

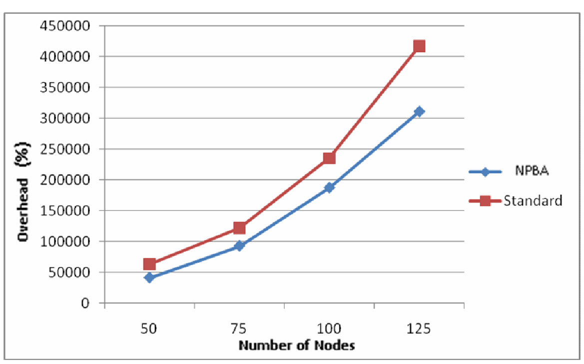

Figure 6. Overhead vs. Number of nodes, with speed =10

In Figure 7 it can be noticed that at low density, our protocol and the AODV have almost identical normalized load values. However for high density values, our protocol become evidently superior with 46% enhancement score**.**

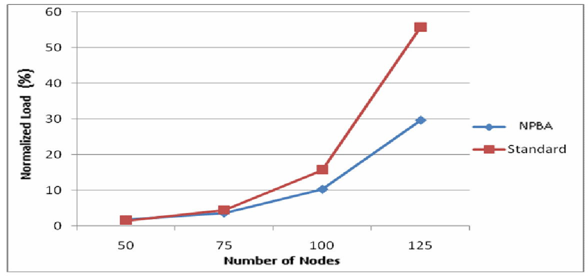

Figure 7. Normalized load vs. Number of nodes, with speed =10

Figure 8 shows that for different network density and as the nodes density increases in the Ad Hoc network, the packets delivery ratio decreased. In addition, the Figure shows that increasing the number of nodes results in lower delivery ratio for all protocols compared.

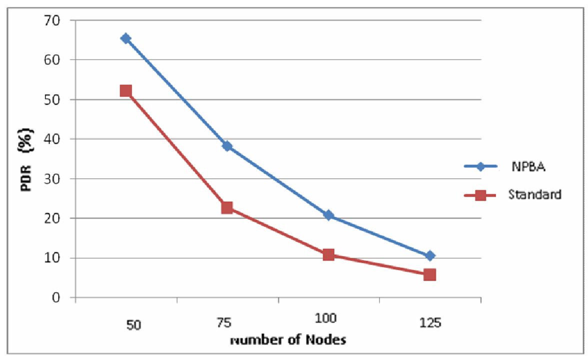

Figure 8. Packet delivery ratio vs. Number of nodes, with speed =10

VI. CONCLUSION AND FUTURE WORKS

In this paper, a new scheme of reactive routing protocols is proposed to decrease the effects of the broadcast storm problem and to discover best route with minimum cost to maximize the throughput and minimize routing overhead and the average end-to-end delay. The major contributions of our protocol are The NPBA is reliable broadcast-based protocols that avoid the negative attitude of simple flooding, which causes a very high overhead. We minimize number of redundant broadcast message, contention and collision by allowing only specific nodes to participate on broadcast propagation. For future works, it would be interesting to compare the performance of our proposed protocol with a dynamic probabilistic algorithm on a Dynamic source Routing protocol (DSR).

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