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Performance evaluation with different mobility models for dynamic probabilistic flooding in MANETs

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Abstract. Broadcasting is an essential and effective data propagation mechanism, with several of important applications such as route discovery, address resolution, as well as many other network services. As data broadcasting has many advantages, also causing a lot of contention, collision, and congestion, which induces what is known as "broadcast storm problems". Broadcasting has traditionally been based on the flooding protocol, which simply overflows the network with high number of rebroadcast messages until the messages reach to all network nodes. A good probabilistic broadcasting protocol can achieve higher saved rebroadcast, low collisions and less number of relays. In this paper, we propose a dynamic probabilistic approach that dynamically fine-tunes the rebroadcasting probability according to the number of neighbour's nodes distributed in the ad hoc network for routing request packets (RREQs). The performance of the proposed approach is investigated and compared with the simple AODVand fixed probabilistic schemes using the GloMoSim network simulator under different mobility models. The performance results reveal that the improved approach is able to achieve higher saved rebroadcast and low collision as well as low number of relays than the fixed probabilistic scheme and simple AODV.

Keywords: AODV, MANETs, probabilistic broadcasting, reachability, performance, collisions

1. Introduction

Mobile Ad hoc Networks (MANETs) consist of a set of wireless mobile nodes. A node can directly communicate with its neighbours without relying on any pre- existing infrastructure in the network. More accurately, a message sent by one a mobile node in the network can reach all its neighbours within its transmission radius [6]. Since not every mobile node in a MANET can communicate directly with the nodes located outside its communication range, a rout request packet may have to be rebroadcast several times at relaying mobile node in order to guarantee that the packet can reach all nodes. Wireless and self-configuring characters of MANETs make them appropriate for multiple applications [15]. These include military operations, rescue and disaster recovery situations [6,15]. Other applications of MANETs are in data acquisition in hostile territories, virtual classrooms, and temporary local area networks.

A general and basic operation in ad hoc networks is broadcasting whereby a source node transmits a message that is to be disseminated to all the nodes in the network. In the one-to- all models, transmission by each node can reach all nodes that are within its transmission radius, while in the one-to-one model, each transmission is directed toward only one neighbour using narrow beam directional antennas or separate frequencies for each node [3]. It can also be used for route discovery reactive protocols in ad-hoc networks. For example, in Ad Hoc On-demand Distance Vector Routing (AODV), Dynamic Source Routing (DSR), Zone Routing Protocol (ZRP) [14], and Location Aided Routing (LAR) [3], in the network a route request is broadcasted. Every node remains the broadcast ID and the name of the node from which the message has been received. As soon as the correspondent is reached, it replies with a unicast (point-to-point) message and then each intermediate mobile node is capable to establish the return route.

Flooding is commonly used for broadcasting. Each node, that receives a broadcast message for the first time, rebroadcasts it to its neighbours [1]. The only 'optimisation' applied to this technique is that nodes remember broadcast messages received and do not rebroadcast if they receive repeated copies of the same message [14]. This is very simple and needs only some resources in the nodes. This approach offers the advantage to be reliable, but produces a high overhead in the network. The probability of multiple requests at the same time for medium access is very high and the number of collisions dramatically increases, which causes a lot of dropped packets, such a scenario has often been referred to as the broadcast storm problem [1,7,10]. A number of researchers have identified this problem by showing how serious it is through analyses and simulations [1]. A probabilistic approach for flooding has been suggested in [3,12,13] as a means of reducing redundant rebroadcasts and alleviating the broadcast storm problem. In the probabilistic scheme, when receiving a broadcast message for the first time, a node rebroadcasts the message with a pre-determined probability p; every node has the same probability to rebroadcast the message. When the probability is 100%, this scheme reduces to simple flooding. The studies of [10] have shown that probabilistic broadcasts incur significantly lower overhead compared to blind flooding while maintaining a high degree of propagation for the broadcast messages.

More solutions include probabilistic (gossip-based) [15,17], counter-based [15], distance-based [1, 15], location-based [15] and cluster-based [1,15]. In the probabilistic schemes, a host rebroadcasts the message with a fixed probability P. The counter-based scheme broadcasts message when the number of received copies at the host is less than a threshold.

One of the important problems in the ad hoc network is to reduce the number of necessary message for broadcast. In this paper, we propose a dynamic probabilistic broadcast approach that can efficiently reduce broadcast redundancy in mobile wireless networks. The proposed algorithm dynamically calculates the host rebroadcast probability according to number of neighbour nodes of the host.

The rebroadcast probability would be low when the numbers of neighbour nodes are high which means host is in dense area and the probability would be high when the number of neighbour nodes is low which means host is in sparse area.

To measure network performance three significant matrices, collision, saved rebroadcasts and relays are used under different mobility models.

We evaluate our proposed approach against the fixed probabilistic approach by implementing them in a modified version of the AODV protocol. The simulation results show that broadcast redundancy can be significantly reduced through the proposed approach in all mobility scenarios.

The rest of this paper is configured as follows: Section 2 introduces the background and related work of broadcasting in MANETs. In Section 3, we present the proposed dynamic probabilistic approach, highlighting its distinctive features from the other similar techniques. Section 4 provides an overview of different mobility models in MANETs. The parameters used in the experiments and the performance results and analyses of the behaviour of the broadcasting algorithm are presented in Section 5. Section 6 concludes the paper and suggestions for the future work.

2. Related work

Flooding is one of the earliest broadcast mechanisms in wired and wireless networks. Upon receiving the message for the first time, each node in the network rebroadcasts a message to its neighbours. While flooding is simple and easy to implement, it can affect the performance of a network, and may lead to a serious problem, often known as the *broadcast storm problem* [1,15] which is exemplified by large number of redundant rebroadcast packets, collision and network bandwidth contention. Ni et al. [15] have studied the flooding protocol experimentally and analytically. Their results have indicated that rebroadcast could provide at most 61% additional coverage and only 41% additional coverage in average over that already covered by the previous broadcast attempt. Consequently, they have concluded that retransmits are very costly and should be used with warning. Authors in [15] have classified existing broadcasting techniques into five classes with respects to their ability to reduce contention, collision, and redundancy. The classes consist of probabilistic, counter-based, distance-based, location-based and cluster-based. For each of these classes a brief description is provided in the following. In the probabilistic scheme, a host node rebroadcasts messages according to a certain probability. In the counter-based scheme, a node determines whether to rebroadcast a message or not by counting how many the same messages, it has received during a random period of time. The counter based scheme supposes that the expected additional coverage is so small that rebroadcast would be ineffective when the number of recipient broadcasting messages exceed a certain threshold value.

The distance-based scheme uses the relation distance between a host node and the previous sender to make a decision whether to rebroadcast a message or not. The location-based scheme rebroadcasts the message if the additional coverage due to the new emission is larger than a certain pre-fixed bound.

The cluster-based scheme divides the ad hoc network into several clusters of mobile nodes. Every cluster has one cluster head and a number of gateways. The cluster head is a representative of the cluster whose rebroadcast can cover all hosts in that cluster. Only gateways can communicate with other clusters and have responsibilities to disseminate the broadcast message to other clusters. Another classification for broadcasting techniques in MANETs also could be found in [1]. This study has classified the broadcasting techniques into the following four categories: simple flooding, probability-based, area-based, and neighbour knowledge schemes. In the flooding scheme, each node rebroadcasts to its neighbours as a response to every recently received message. The probability-based scheme is a very simple method of controlling message floods. Every node rebroadcasts with a fixed probability p [13]. Clearly when $p = 1$ this scheme be similar to simple flooding. In the area based scheme, a node determines whether to rebroadcast a packet or not by calculating and using its additional coverage area [15]. Neighbour knowledge scheme [1] maintains neighbour node information to decide who should rebroadcast. This method requires mobile hosts to explicitly exchange neighbourhood information among mobile hosts using periodic Hello packets. The neighbour list at the present host is added to every broadcast packet. When the packets arrive at the neighbours of the present host, every neighbour compares its neighbour list with the list recorded in the packets. It rebroadcasts the packets if not all of its own neighbours are included in the list recorded in the packets. The length of the period affects the performance of this approach. Very short periods could cause contention or collision while too long periods may debase the protocol's ability to deal with mobility.

Cartigny and Simplot [6] have described a probabilistic scheme where the probability p of a node for retransmitting a message is computed from the local density n (i.e., the number of neighbours) and a fixed value k for the efficiency parameter to achieve the reachability of the broadcast. This technique has the drawback of being locally uniform. In fact, each node of a given area receives a broadcast and determines the probability according to a constant efficiency parameter (to achieve some reachability) and from the local density [6].

Zhang and Dharma [8] have also described a dynamic probabilistic scheme, which uses a combination of probabilistic and counter-based schemes. This scheme dynamically adjusts the rebroadcast probability p at every mobile host according to the value of the packet counters. The value of the packet counter does not necessarily correspond to the exact number of neighbours from the current host, since some of its neighbours may have suppressed their rebroadcasts according to their local rebroadcast probability. On the other hand, the decision to rebroadcast is made after a random delay, which increases latency.

Bani Yassein et al. [7,16] have proposed fixed pair of adjusted probabilistic broadcasting scheme where the forwarding probability p is adjusted by the local topology information. Topology information is obtained by proactive exchange of "HELLO" packets between neighbours to construct a 1-hope neighbour list at every host. The adjusted probabilistic flooding scheme is a combination of the probabilistic and knowledge based approaches. For both approaches presented in [8,16] there is an extra overhead i.e., before calculating the probability, average number of neighbour nodes should be known in advance.

With the broadcasting methods described above, the simplest one is flooding, which also produces the highest number of redundant rebroadcasts. The probabilistic approaches reduce the number of rebroadcasts at the expense of reachability. Counter-based algorithms have better reachability and throughput, but suffering from relatively longer delay. Area-based algorithms need support from GPS or other location devices, and the neighbour-knowledge-based approaches require the exchange of neighbourhood information with hosts. Here, we propose a new probabilistic approach that dynamically fine-tunes the rebroadcasting probability for routing request packets (RREQs) according to the number of its neighbour nodes to yield higher saved rebroadcast, few collisions, and lower rout request. We describe the details of our approach in the following section.

3. Dynamic probabilistic algorithms

As studied previously, traditional flooding suffers from the redundant message reception problem [15]. The same message is received several times by each node, which is inefficient, wastes valuable resources and can cause high contention in the broadcasting medium. In fixed probabilistic flooding the rebroadcast probability p is fixed for every node [13]. This method is one of the alternative approaches to flooding that aims to limit the number of redundant transmissions. In this scheme, when receiving a broadcast message for the first time, a node rebroadcasts the message with a pre-determined probability p. Thus every node has the same probability to rebroadcast the message, regardless of its number of neighbors.

In dense networks, multiple nodes share similar transmission ranges. Therefore, these probabilities control the number of rebroadcasts and thus might save network resources without affecting delivery ratios. Note that in sparse networks there is much less shared coverage; thus some nodes will not receive all the broadcast packets unless the probability parameter is high. Therefore, setting the rebroadcast probability P to a very small value will result in a poor reachability. On the other hand, if P is set to a very large value, many redundant rebroadcasts will be generated.

A brief sketch for the dynamic probabilistic flooding algorithm is shown below and works as follows. On hearing a broadcast message *msg* at host node N for the first time, the node rebroadcasts a message according to a calculated probability with the help of neighbour nodes of N, Therefore, if node N has a high probability P, rebroadcast should be likely. Otherwise, if N has a low probability P rebroadcast may be unlikely.

Procedure

Input Parameters:

$pkt(i)$: Packet to relay by i^{th} node.

$p(i)$: Rebroadcast probability of packet (*pkt*) of ith node.

$RN(i)$: Random Number for i^{th} node to compare with the rebroadcast probability p.

$n_{nbr}(i)$: Number of neighbour nodes of i^{th} node.

$nbrTable(i)$: Neighbour table for i^{th} node

Output Parameters:

$Discpkt(i)$: Packet (*pkt*) will be discarding by the i^{th} node, if it is already in its list.

$Rbdpkt(i)$: Packet (*pkt*) will be rebroadcast by i^{th} node, if probability p is high.

$Drpkt(i)$: Packet (*pkt*) will be dropped by i^{th} node, if probability p is low.

Calculation of Broadcasting probability upon receiving a braodcast packet (pkt)

if a packet (*pkt*) *is* received for the 1^{st} time at the i^{th} node **then**

{

get nbrTable(*i*)

if size (nbr Table(i)) = = 0 then

return (0)

else

{

$p_{\max} = 0.9;$

$p_{\min} = 0.4$

$$S_n = p_{\max} \sum_{n=0}^{nbr} p_{\max}^n$$

$$S_n = p_{\max} \frac{\left(1 - p_{\max}^{nbr}\right)}{1 - p_{\max}}$$

where $n = 1, 2, 3, \ldots$

To get value of p for any term at i^{th} node

$$P(i) = S_n - S_{n-1}$$

Since we have $p_{\max}^n$ and as: $0 < p_{\max} < 1$.

This term will get close to zero as (n_{nbr}) get large, so we can get that the some of infinity is:

$$S\infty = \frac{1}{1 - p_{\max}}$$

The term of $(p_{\max}^{n_{nbr}})$ is omitted as it get smaller or close to infinity.

where $(p_{(i)})$ is current term probability

if $P(i) < p_{\min}$ **then**

{

$P(i) = p_{\min}$

Relay the packet (*pkt*) *when* $(P(i) > RN(i))$

    }
  else
    Drop (*pkt*)
  }
}
else
Drop (*pkt*)

Neighbour informed that nbrTable(i) for ith node is formed by sending periodic hello packets and entries in the table are updated based the replies received from neighbours.

$$P_{(i)} = \begin{cases} P_{\min} \text{ Where } P < P_{\min} \\ P_{\max} \text{ where } P = 1 \end{cases} \quad (1)$$

Equation (1) shows the upper and lower values of p for different number of neighbour nodes, where $p_{\max} = 1$ and $p_{\min} = 0.4$. As by choosing different values of $p_{\min}$ for our dynamic probabilistic flooding algorithm and getting simulation results, we came across the best results while taking $p_{\min} = 0.4$.

The proposed algorithm dynamically calculates the value of rebroadcast probability p. Higher value of p means higher number of redundant rebroadcast where as smaller value of p indicates lower reachability. Hence, the rebroadcast probability p is calculated according to the neighbour nodes information. The value of p would be high in sparser regions where as p would be lower in dense region, as shown in Fig. 1a and 1b.

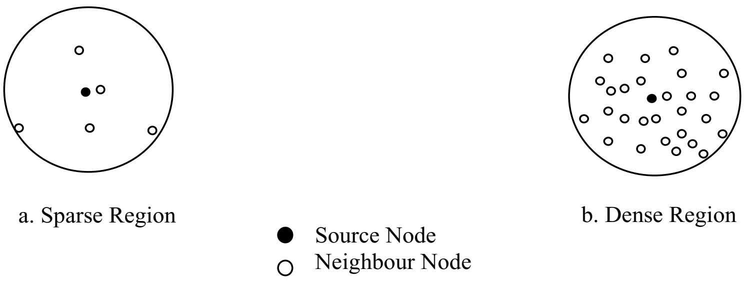

Fig. 1. Sparse and dense region.

4. Mobility models

Appropriate mobility models that can accurately capture the properties of real-world mobility patterns are required for effective and reliable performance evaluation of the MANETs. Due to the different types of movement patterns of mobile users, and how their location, velocity and acceleration change over time, different mobility models should be used to emulate the movement pattern of targeted real life applications. In our study, three different mobility models are considered including Random Waypoint (RWP), Manhattan Grid and Reference Point Group Mobility (RPGM) models.

The RWP mobility model proposed by Johnson and Maltz [4] is the most popular mobility model used in the performance and analysis of the MANETs due to its simplicity. The two main key parameters of the RWP models are $V_{\max}$ and T_{pause} where $V_{\max}$ the maximum velocity for every mobile station and T_{pause} is the pause time. A mobile station in the RWP model selects a random destination and a random

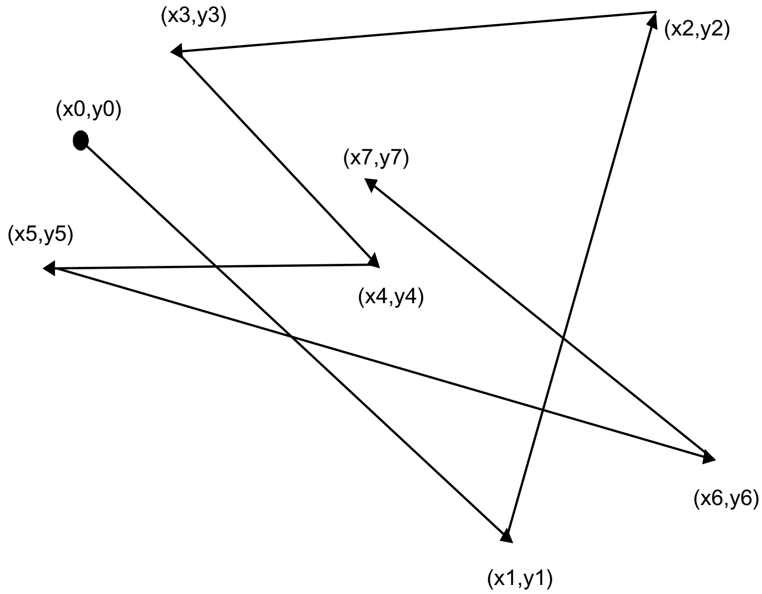

Fig. 2. An example of mobile station movement in RWP model.

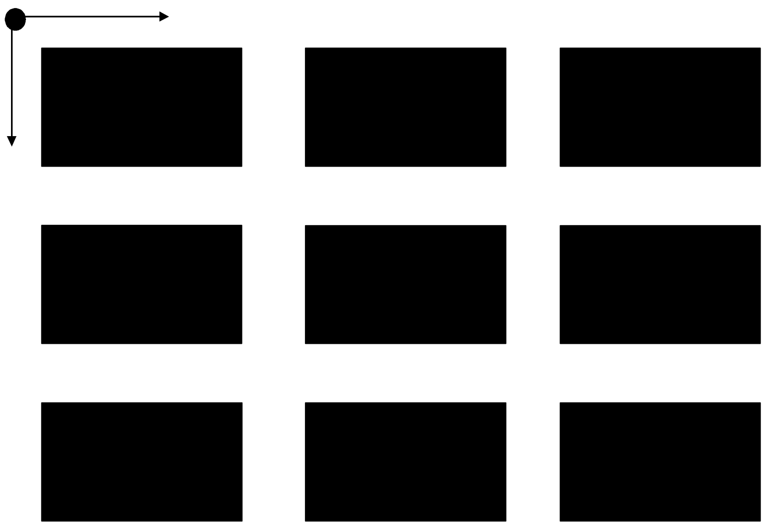

Fig. 3. Example of mobile station movement in Manhattan mobility model.

speed between [0,$V_{\max}$], and then moves towards the selected destination at the selected speed. Upon reaching the destination, the mobile station stops for some pause time T_{pause}, and the repeats the process by selecting a new destination, speed and resuming the movement. Figure 2 shows a movement trace of a mobile station using a RWP mobility model.

Unlike RWP mobility, Manhattan mobility model uses a grid road topology as shown in Fig. 3. Initially, the wireless stations are placed randomly of the edge of the graph. Then the wireless stations move towards a randomly chosen destinations employing a probabilistic approach in the selection of stations movements with probability $^1/_2$ to keep moving in the same direction and $^1/_4$ to turn left or right.

Table 1
Simulation parameters

Simulator	Value
Simulation Parameter	GloMoSim v2.03
Network Range	1000 m × 1000 m
Transmission Range	250 m
Mobile Nodes	70,80,90 and 100
Traffic Generator	Constant Bit Rate (CBR)
Band Width	2 Mbps
Packet size	512 Bytes
Packet Rate	10 Packet per second (pps)
Simulation Time	900 s

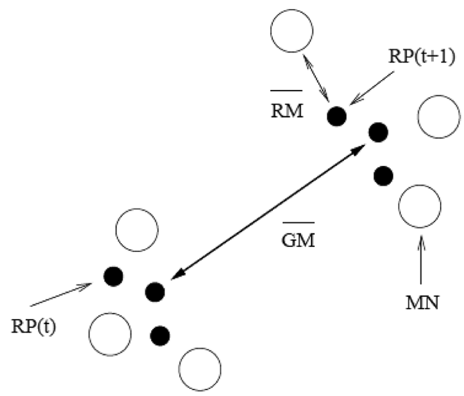

Fig. 4. An example of node movement in Reference Point Group Mobility Model.

In addition to RWP and Manhattan mobility models, the Reference Point Group Mobility (RPGM) model is proposed in [11]. Figure 4 shows an example of node movement in Reference Point Group Mobility Model. In this model, each group has a number of wireless station members and a center, which is either a logical center or a group leader. This model represents the random motion of a group of mobile nodes (MNs) as well as the random motion of every individual MN within the group. The group leader movement determines the mobility behaviors of all other members in the group. The group leader is used to calculate group motion via a group movement vector, $\overline{\mathrm{GM}}$. The movement of the group centre completely characterizes the movement of its corresponding group of MNs, including their direction and speed. Individual MNs randomly move about their own predefined reference points, whose movements rely on the group movement. As the individual reference points move from time t to $t+1$, their locations are updated according to the group's logical centre. Once the updated reference points, RP(t+1), are calculated, they are combined with a random motion vector, $\overline{\mathrm{RM}}$, to represent the random motion of each MN about its individual reference point. One of the real applications which PRGM model can represent it accurately is the mobility behaviors of soldiers moving together in a group.

5. Performance analyses

In this section, we evaluate the performance of the proposed dynamic probabilistic broadcasting algorithm. We compare the proposed algorithm with a fixed probabilistic algorithm. The metrics for comparison include saved rebroadcast, average number of routing request rebroadcasts, and the average number of collisions.

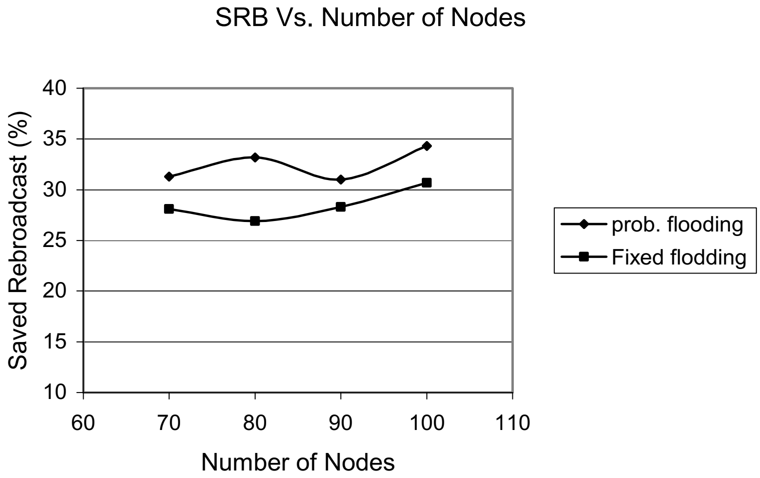

Fig. 5. Saved Rebroadcast comparison between our dynamic probabilistic and fix probabilistic for the RWP mobility model.

5.1. Simulation setup

The GloMoSim network simulator (version 2.03) [12] has been adopted to conduct extensive experiments to evaluate behavior of the proposed dynamic probabilistic flooding algorithm. We study the performance of the broadcasting approaches in the situation of higher level application, namely, the AODV routing protocol [3,13,14] that is included in the GloMoSim package. The original AODV protocol uses simple blind flooding to broadcast routing requests. We have implemented two AODV variations: one using probabilistic method with fixed probability, called FPAODV (AODV + fixed probability), and the other based on dynamically calculating the rebroadcast probability for each node, called P-AODV (AODV + dynamic probability). In our simulation, we use a 1000 m $\times$ 1000 m area with different number of mobile hosts. The network bandwidth is 2 Mbps and the medium access control (MAC) layer protocol is IEEE 802.11 [8]. Other simulation parameters are shown in Table 1.

The main idea behind the proposed approach is to reduce the rebroadcasting number in the route discovery phase, thus reducing the network traffic and decrease the probability of channel contention and packet collision.

Since our algorithm is based on a probabilistic approach, it does not fit every scenario, as there is a small chance that the route requests cannot reach the destination. It is necessary to re-generate the route request if the previous route request failed to reach the destination. We study the performance of the broadcast approaches in these scenarios.

5.2. Saved Rebroadcast (*SRB*)

In our algorithm, the rebroadcast probability is dynamically calculated. In sparser area, the probability is high and in denser area the probability is low. SRB is the ratio of the number of route request (RREQs) packets rebroadcasted over total number of route request (RREQs) packets received, excluding those expired by time to live (TTL).

As an effort to investigate the performance of our dynamic probabilistic algorithm, Figs 5, 6 and 7 compare the saved rebroadcast of the fixed probabilistic and proposed dynamic probabilistic under three different mobility models scenarios. For the RWP scenario (Fig. 5), our improved algorithm can

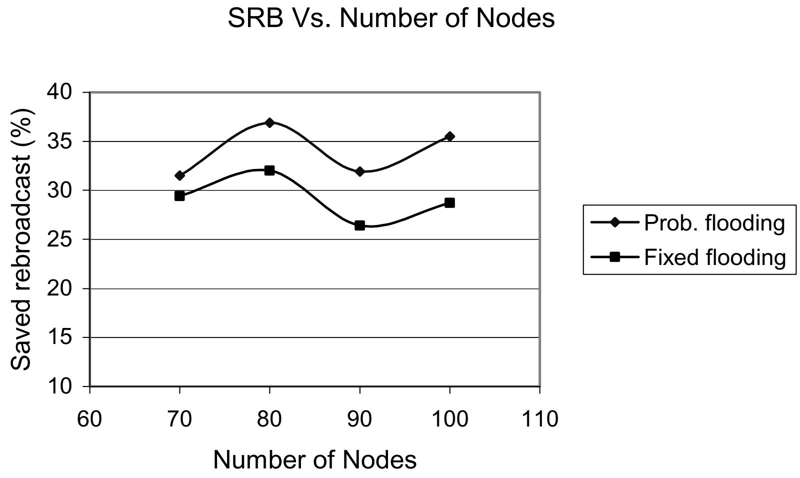

Fig. 6. Saved Rebroadcast comparison between our dynamic probabilistic and fix probabilistic for the Manhattan mobility model.

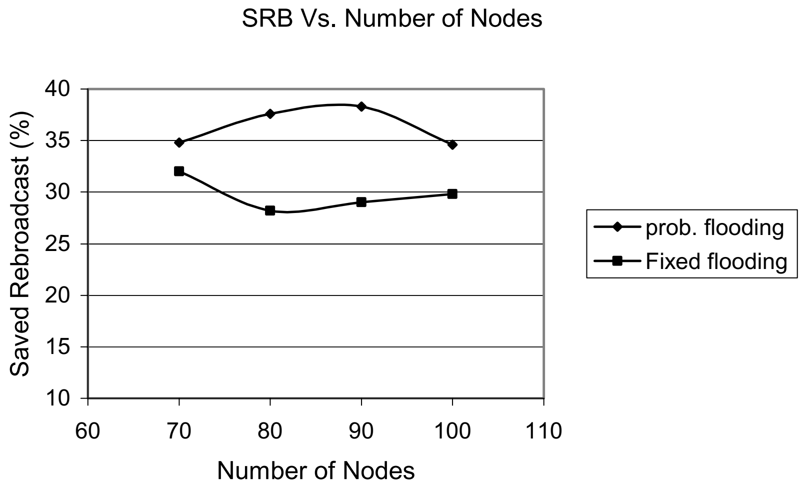

Fig. 7. Saved Rebroadcast comparison between our dynamic probabilistic and fix probabilistic for the RPGM mobility model.

significantly reduce the rebroadcast for network with different number of nodes, and 10 source-destination pair's connections and achieves a higher saved rebroadcast than the fix probabilistic (FP-AODV).

Moreover, Fig. 6 shows the saved rebroadcast of the fixed probabilistic and the proposed dynamic probabilistic under Manhattan mobility scenario. As a result for Manhattan mobility model scenario, also our algorithm can achieve better saved rebroadcast than the fixed probabilistic.

Furthermore Fig. 7 reveals the saved rebroadcast of our algorithm and the fixed probabilistic under RPGM mobility model. From the figure, our algorithm has better achievement than that of the fixed probabilistic.

Figure 8 also clears that under the RPGM mobility model scenario our algorithm archives better saved rebroadcast than the RWP and Manhattan mobility model scenarios. This is because of the random behaviour of the RWP and Manhattan mobility model.

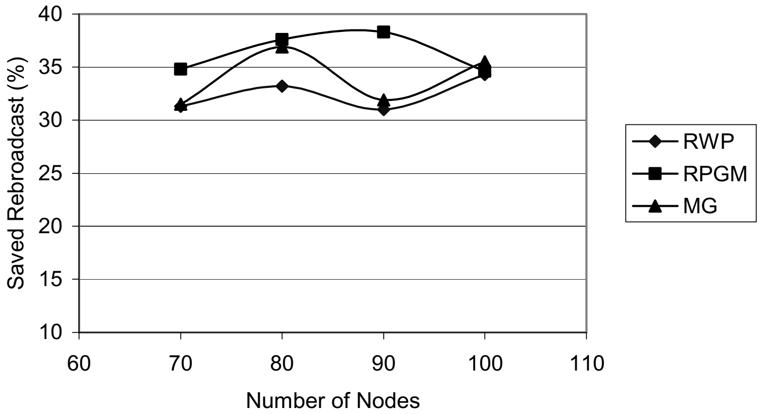

Fig. 8. Comparison of Saved Rebroadcast for our dynamic probabilistic under RWP, RPGM and MG mobility model.

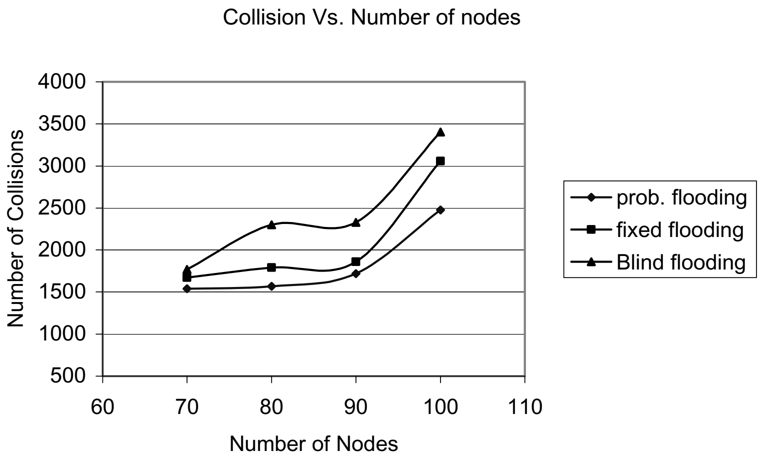

Fig. 9. Collision comparison between our dynamic probabilistic, FP-AODV and Blind AODV for the RWP mobility model.

5.3. Collisions

We measure the number of collisions for these schemes at the physical layer. Since data packets and control packets share the same physical channel, the collision probability is high when there are a large number of control packets. Figures 9, 10 and 11 represent a comparison of collision between our algorithm, FP-AODV and Blind AODV under different mobility models.

As shown in the Fig. 9 (RWP scenario), our algorithm incurs fewer numbers of collisions than that of the FP-AODV and Blind AODV.

Moreover, similar behaviour is observed for the scenario of the Manhattan mobility model (Fig. 10). Our algorithm, FP-AODV and Blind AODV achieved less collision compared with the scenarios of the RWP mobility model. This is due to the random movement pattern of the RWP mobility model which is leaded to break the connection between the source nodes and the destination nodes.

Additionally, Fig. 11 shows the collision of our algorithm, FP-AODV and Blind AODV under RPGM model. As shown in the figure, our algorithm has a lower collision than the FP-AODV and Blind AODV. It is clear that the scenario of the RWP mobility model suffer from very high collision in all scenarios.

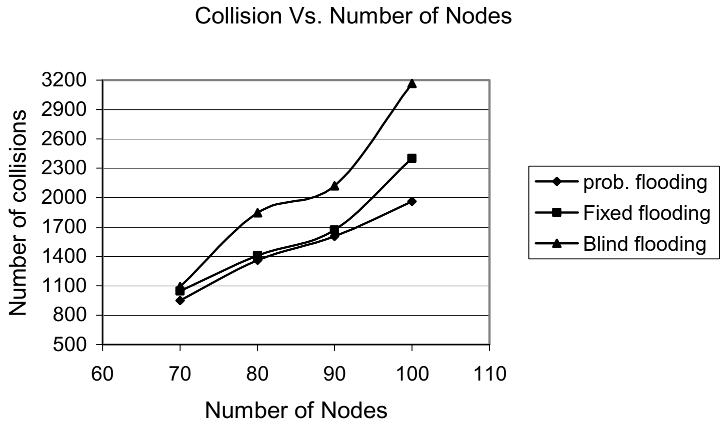

Fig. 10. Collision comparison between our dynamic probabilistic, FP-AODV and Blind AODV for the Manhattan mobility model.

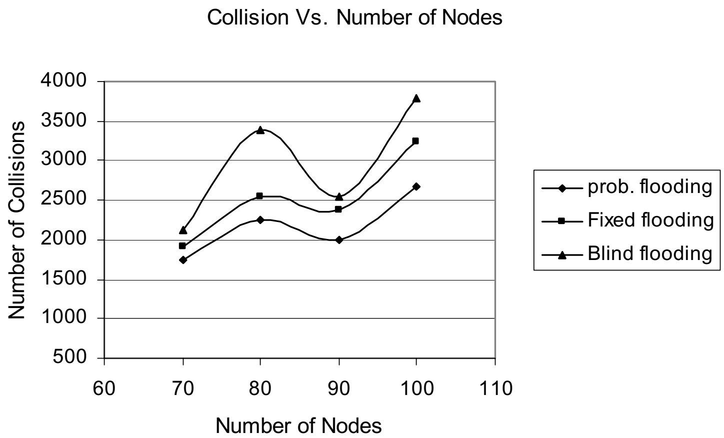

Fig. 11. Collision comparison between our dynamic probabilistic, FP-AODV and Blind AODV for the RPGM mobility model.

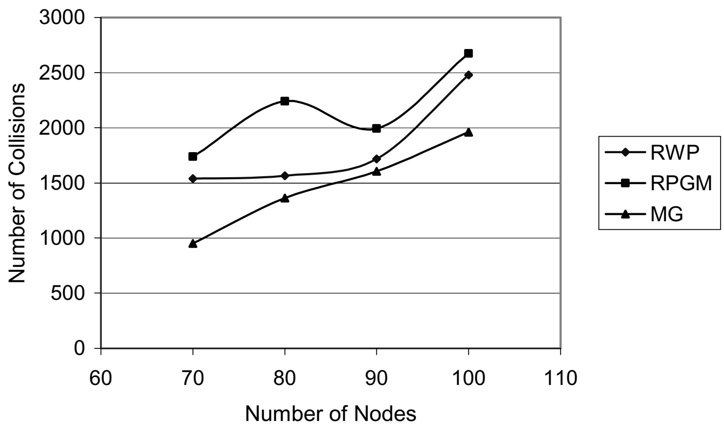

Fig. 12. Comparison of collision for our dynamic probabilistic under RWP, RPGM and MG mobility model.

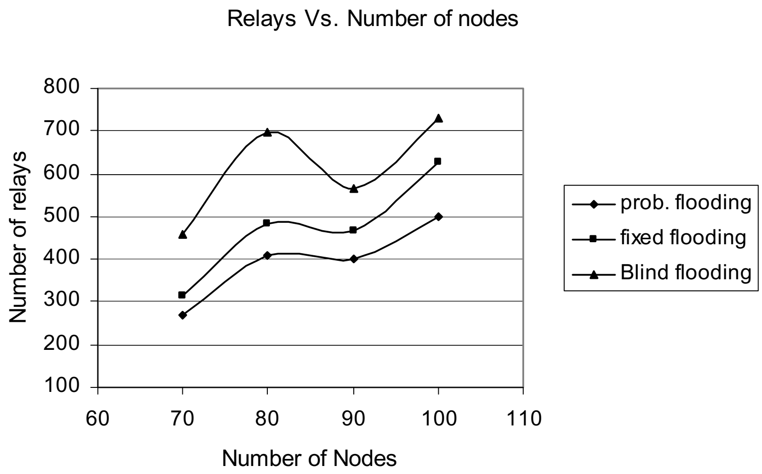

Fig. 13. Comparison of Relays between our dynamic probabilistic, FP-AODV and Blind AODV for the RWP mobility model.

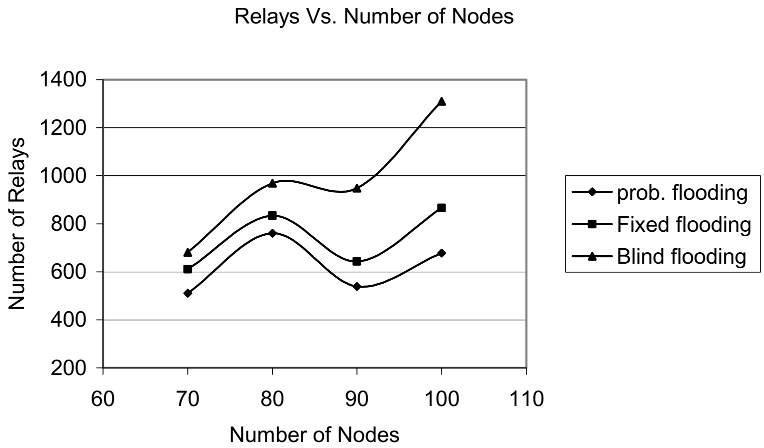

Fig. 14. Relays comparison between our dynamic probabilistic, FP-AODV and Blind AODV for the Manhattan mobility model.

It is worth noting that under different mobility models our algorithm outperforms the FP-AODV and Blind AODV. Moreover, in Fig. 12 our algorithm in case of collision under Manhattan mobility models is significantly lower than that of under RWP or RPGM mobility models. This is because of the different characteristics of the mobility pattern of each model.

After we introduce mobility, more route requests are generated and some of them may fail to reach their destinations. Such failures cause another round of transmission of route request packets. Figure 13 shows the number of relays of our algorithm, FP-AODV and Blind AODV under RWP model. As shown in Fig. 13, the proposed algorithm has lower relays numbers than FP-AODV and Blind AODV.

In Fig. 14, we compare Relays for Manhattan mobility model. The figure shows our algorithm incurs lower relays. As a result, for rout request, our scheme can definitely perform better than FP-AODV and Blind AODV in these scenarios.

Figure 15 shows the performance with RPGM mobility model. Dou to increasing the number of mobile nodes in the network with mobility, more route requests fail to reach the destinations. In these cases, more route requests are generated. The figure implies that our dynamic probabilistic approach can

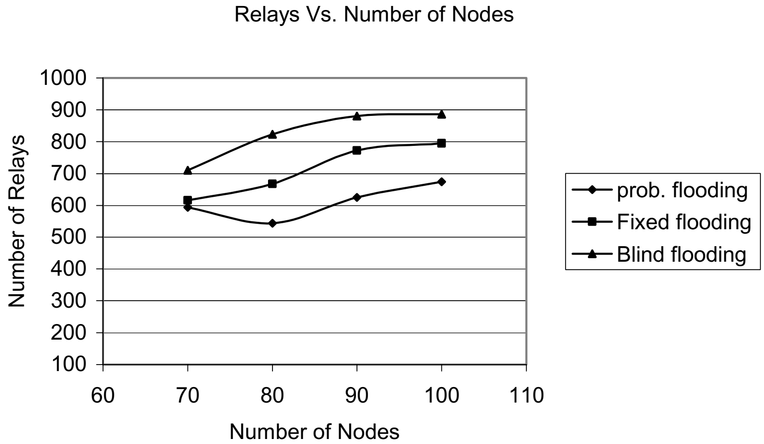

Fig. 15. Relays comparison between our dynamic probabilistic, FP-AODV and Blind AODV for the RPGM model.

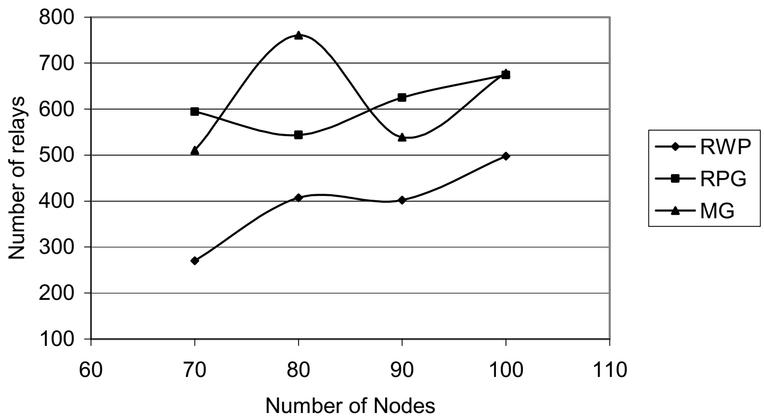

Fig. 16. Comparison of Relays for our dynamic probabilistic under RWP, RPGM and MG mobility model.

achieve less rout request than FP-AODV and Blind AODV in this mobility model too. Figure 16 shows the number of relays for our algorithm under RWP, RPGM and MG mobility model. The figure also obvious that under RWP mobility model scenario our algorithm archives fewer relays than the RPGM and Manhattan mobility model scenarios.

6. Conclusions

In this paper we propose a dynamic probabilistic broadcasting scheme for mobile ad hoc networks where nodes move according to different mobility models. The proposed approach dynamically sets the value of the rebroadcast probability for every host node according to the neighbor's information. The performances of the simulation results have shown that the proposed approach outperforms the FP-AODV in terms of saved rebroadcast under different mobility models. It also demonstrates lower collision and generates less route request than the FP-AODV and simple AODV in all mobility scenarios.

For future work it would be interesting to evaluate the Performance of dynamic probabilistic flooding on the Dynamic Source Routing (DSR) with different mobility models representing more realistic scenarios.

We also plan to make an analytic model for our proposed algorithm in order to facilitate the exploration of the optimal adaptation strategy.

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