PERFORMANCE EVALUATION OF ENHANCED ROUTING DISCOVERY UNDER DIFFERENT MOBILITY MODELS IN MANETs

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ABSTRACT

Broadcasting is a basic data dissemination technique, which has a number of applications such as address resolution, route discovery, as well as many other network services. While data broadcasting has many advantages, it introduces some problems known as broadcast storm problems, which causing a lot of contention, redundant retransmission and collision. In this paper our objective is to reduce the number of retransmission in the broadcast as well as to obtain less number of collisions in the network. An appropriate probabilistic broadcast method can attain high save rebroadcast and low collision. In this paper, we propose a probabilistic approach that calculates the rebroadcast 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 AODV, adjusted probabilistic flooding [4,7] and dynamic probabilistic flooding [13] using the GloMoSim network simulator under waypoint mobility model. Simulation results show our improved approach performs better than simple flooding, adjusted probabilistic flooding [4,7] and dynamic probabilistic flooding [13]. The simulation results reveal that the proposed approach demonstrates better performance than the existing approaches.

KEYWORDS

Flooding, Broadcasting, Collisions, AODV, Transmission

1 INTRODUCTION

Ad hoc networks are a set of wireless mobile nodes which communicate with each another without relying on any pre-existing routing infrastructure for communication, but instead communicate either directly or with the help of other intermediate nodes in the network. The disseminated, wireless and self-configuring character of ad hoc networks make them appropriate for a wide variety of applications. Ad hoc networks are helpful in many situations where unprepared communication facilities are required, such as disaster relief missions and battlefield communication facilities [1, 2].

Broadcasting is a general and basic operation in ad hoc networks whereby a source node transmits a packet so that each node in a network receives a copy of this packet. For example, on-demand routing protocols such as ad-hoc on demand distance vector (AODV) [8], dynamic source routing (DSR) [12] and Zone Routing Protocol (ZRP) [11] use the broadcast information in route request packets to construct routing ables at every mobile node. The lively nature of MANETs, however, requires the routing protocols to refresh the routing tables regularly, which could generate a large number of broadcasting Packets at various nodes. Since not every node in a MANET can communicate directly with the nodes outside its communication range, a broadcast packet may have to be rebroadcast several times at relaying nodes in order to guarantee that the packet can reach all nodes. Consequently, an inefficient broadcast approach may generate many redundant rebroadcast packets [5].

There are many proposed approaches for broadcasting in MANETs. The simplest one is the flooding. In this technique, each mobile host rebroadcasts the packets when received for the first time. Packets that have already been received are just droped. Though flooding is simple, it consumes much network resources as it introduces a large number of duplicate messages. It leads to serious redundancy, contention and collision in mobile wireless networks, which is referred to “broadcast storm problem” [5, 6, 7].

A number of researchers have identified this problem by showing how serious it is through analyses and simulations [6]. A probabilistic approach for flooding has been suggested in [8,10,11] as a means of reducing redundant rebroadcasts and alleviating the broadcast storm problem.

In this paper, we propose a new probabilistic approach that dynamically fine-tunes the rebroadcasting probability for routing request packets (RREQs) in Ad-Hoc networks where the forwarding probability p is dynamically adjusted by the local topology information. Topology information is obtained by proactive exchange of “HELLO” packets between neighbours.

Four significant matrices to measure network performance, saved rebroadcasts, collision, relays and reachability are used under random waypoint mobility model [14].

We evaluate our proposed approach against the simple AODV, adjusted probabilistic flooding [4,7] and dynamic probabilistic flooding [13] by implementing them in a modified version of the AODV protocol. The simulation results demonstrate that broadcast redundancy can be greatly reduced during the proposed approach.

The rest of this paper is arranged as follows: Section 2 the background and related work of broadcasting in MANETs. In section 3, we present the enhanced dynamic probabilistic approach. Section 4 introduces the major mobility models of MANETs. The parameters used in the experiments and the performance results and analyses of the behaviors of the broadcasting algorithm are presented in Section 5. Section 6 concludes the paper and suggestions for the future work.

2 BACKGROUND

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 [2, 6] which is exemplified by large number of redundant rebroadcast packets, collision and network bandwidth contention.

There are five proposed flooding schemes [6] in MANETs called probabilistic, counter-based, distance-based, location-based [2] and cluster-based [2, 6]. In the probabilistic scheme, a host node will rebroadcasts the message when received for the first time, according to fixed probability P. The counter-based scheme rebroadcast the message if the message has been received for more than C times. In the distance-based scheme a node rebroadcasts the message only if the distance between the source and the receiver is larger than a threshold D.

The location-based scheme rebroadcasts the message if the additional coverage due to the new emission is larger than a bound A. Finally, the cluster-based scheme uses a cluster selection algorithm to create the clusters, and then the rebroadcast is done by head clusters and gateways. The authors conclude by the efficiency of the location-based scheme [2], but these additional area coverage protocols need a positioning system.

Zhang and Dharma [3] have also described a dynamic probabilistic scheme, which uses a combination of probabilistic and counter-based schemes. The number of a packet counter does not necessarily match up to the correct number of neighbours from the recent host, since some of its neighbours may have suppressed their rebroadcasts according to their local rebroadcast probability. Alternatively, the decision to rebroadcast is done after a random delay, which cause more latency.

Bani Yassein et al. [4,7] 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.
Hanashi, A. M. et al. [13] have proposed a probabilistic approach that dynamically calculates the rebroadcast probability according to the number of neighbour's nodes distributed in the ad hoc network for routing request packets (RREQs).
Here, we propose a new probabilistic broadcast approach that can efficiently reduce broadcast redundancy in mobile wireless networks where the forwarding probability p is dynamically adjusted by the local topology information. Topology information is achieved by proactive exchange of "HELLO" messages between neighbours. We explain the details of our approach in the following section.

3 DYNAMIC PROBABILISTIC FLOODING ALGORITHM

The probabilistic scheme [2] is one of the alternative scheme to simple flooding that's objective is to reduce redundancy through rebroadcast moment control in an attempt to alleviate the broadcast storm problem. In this method, when node receives a broadcast message for the first time, will rebroadcasts the message with a fixed probability p so that every node has the same probability to rebroadcast the message, despite its number of neighbours.
In crowded area, a number of hosts share similar broadcast ranges. Consequently, these probabilities control the number of rebroadcasts and thus might save network resources without affecting delivery ratios. Note that in sparse area there is much less shared coverage; thus some hosts will not receive all the broadcast packets unless the probability parameter is high.
Our enhanced algorithm is a combination of the dynamic probabilistic [13] and knowledge based approaches. It dynamically adjusts the re-broadcast probability P at every mobile node according to the value of the local number of neighbours. We calculate the average number of neighbours for the selection of the value of P by using equation 1 [4,7]. Let A be the area of an ad hoc network, N be the number of mobile nodes in the network. The average number of neighbour can be obtained as shown below.

$$\overline{nbr} = (N-1) \times 0.8 \times \frac{\pi r^2}{A}$$

Enhanced probabilistic broadcasting algorithm

This algorithm relays the packet (pkt) for ith node with probability *P*.

Input Parameters:

$pkt(i)$: Packet to relay by ith node.
p(i): Rebroadcast probability of packet (pkt) of ith node.
$RN(i)$: Random Number for ith node to compare with the rebroadcast probability *p*.
$S_{nbr}(i)$: Number of neighbour nodes of ith node.

$\overline{nbr}$: Average number of neighbour (threshold value).

Output Parameters:

$Discpkt(i)$: Packet (pkt) will be discarding by the ith node, if it is already in its list.
$Rbdpkt(i)$: Packet (pkt) will be rebroadcast by ith node, if probability *p* is high.
$Drpkt(i)$: Packet (pkt) will be dropped by ith node, if probability *p* is low.

Upon receiving a packet *(pkt)* at ith node
if packet *(pkt)* received for the 1st time **then**
  If $S_{nbr}(i) < \overline{nbr}$ **then**
ith node has a low degree:

$$P := \prod_{i=0}^{S_{nbr(i)}} P * P_{\max}$$

  if $p < p_{min}$ **then**
   $p = p_{min}$
  end if
return (P)
else
ith node has a high degree:
drop the packet ($Drpkt(i)$)
  end if
end if
Generate a random number RN over [0, 1].
Relay the packet ($Rbdpkt(i)$) *when* ($P > RN(i)$)
  else
    $Drpkt(i)$
end if
Where P_{max}= 0.9 and P_{min}=0.4

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) [14], Manhattan Grid [14] and Reference Point Group Mobility (RPGM)[14] models.

The RWP mobility model proposed by Johnson and Davies [14] 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 $V_{\max}$ is 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 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. Unlike RWP mobility, Manhattan mobility model uses a grid road topology [14]. 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 ½ to keep moving in the same direction and ¼ to turn left or right. In addition to RWP and Manhattan mobility models, the Reference Point Group Mobility (RPGM) model is proposed in [15]. 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 as well as the random motion of each individual mobile node within the group. The movement of the group leader determines the mobility behaviours of all other members in the group. One of the real applications which RPGM model can represent it accurately is the mobility behavior of soldiers moving together in a group.

5 PERFORMANCE ANALYSES

In this section, we evaluate the performance of the enhanced dynamic probabilistic broadcasting algorithm. We compare the proposed algorithm with the simple AODV, adjusted probabilistic flooding [4,7] and dynamic probabilistic flooding algorithm [14]. The metrics for comparison include average saved rebroadcast, average number of routing request rebroadcasts, and the average number of collisions.

5.1 Simulation Setup

The GloMoSim network simulator (version 2.03) [9] has been adopted to conduct extensive experiments to evaluate behavior of the proposed probabilistic flooding algorithm. In our simulation, we use a 1000m X 1000m area with 100 mobile nodes. The network bandwidth is 2Mbps and the MAC layer protocol is IEEE 802.11 [3]. Other simulation parameters are shown in Table 1.

Table 1. Simulation Parameters

Simulation Parameter	Value
Simulator	GloMoSim v2.03
Network Range	1000m×1000m
Transmission Range	250m
Mobile Nodes	100
Traffic Generator	CBR
Band Width	2Mbps
Packet size	512Bytes
Packet Rate	10 pps
Simulation time	900s

We analysis the performance of the broadcasting approaches in the situation of a higher-level application, namely, the AODV routing protocol [8,10,11] that is included GloMoSim package. The original AODV protocol uses simple (Blind) flooding to transmit routing requests. We have implemented three AODV variations: one using adjusted probabilistic flooding [4, 7] method called AD-AODV (AODV + fixed pair probability), the second one based on dynamically calculating the rebroadcast probability for each node [14], called P-AODV (AODV + dynamic probability) and the third one is our enhanced dynamic algorithm (EDP-AODV)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.

While our algorithm is founded 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 prior route request failed to arrive at the destination. We study the performance of the broadcast approaches in these scenarios.

5.2 Saved Rebroadcast (SRB)

In our algorithm, saved rebroadcast is the ratio of the number of route request packets rebroadcasted over total number of route request packets received, excluding those expired by time to live.

As an effort to investigate the performance of our proposed dynamic probabilistic algorithm, fig.1, fig.2 and fig.3 compare the saved rebroadcast of the adjusted probabilistic flooding [4,7], dynamic probabilistic flooding [13] and enhanced dynamic probabilistic under three different mobility models scenarios. For the RWP scenario (fig.1), our improved algorithm can perform a better SRB for network with different number of source-destination pair's connections with 100 nodes and achieves a higher saved rebroadcast than other schemes.

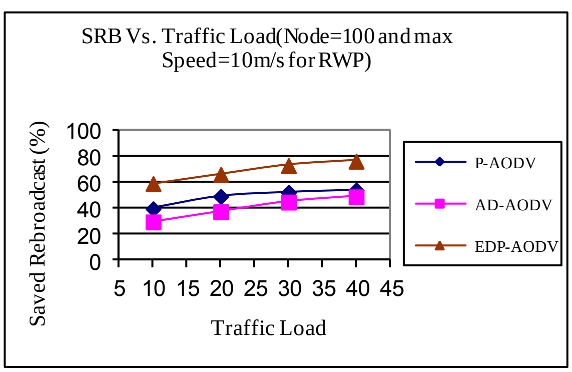

Figure 1. SRB Vs. Traffic Load for RWP

Moreover, Fig.2 shows the saved rebroadcast of the adjusted probabilistic flooding (AD-AODV) [4,7], dynamic probabilistic flooding (P-AODV) [13] and enhanced dynamic probabilistic (EDP-AODV) under Manhattan mobility scenario. As a result for Manhattan mobility model scenario, also our algorithm can achieve better saved rebroadcast than the adjusted probabilistic flooding and dynamic probabilistic flooding.

Furthermore Fig.3 indicates the saved rebroadcast of our algorithm, adjusted probabilistic flooding [4,7] and dynamic probabilistic flooding [13] under RPGM mobility model. From the figure, our algorithm has better achievement than that of the adjusted probabilistic flooding and dynamic probabilistic flooding.

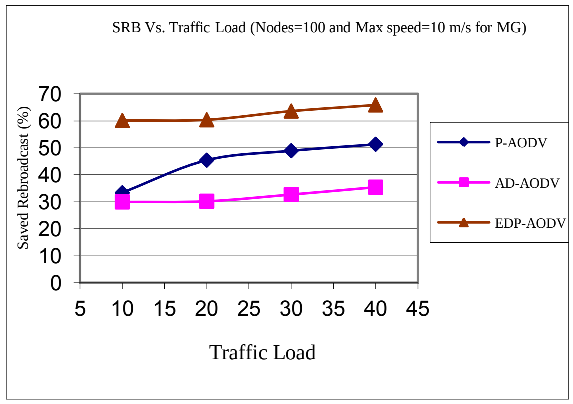

Figure 2. SRB Vs. Traffic loads for MG

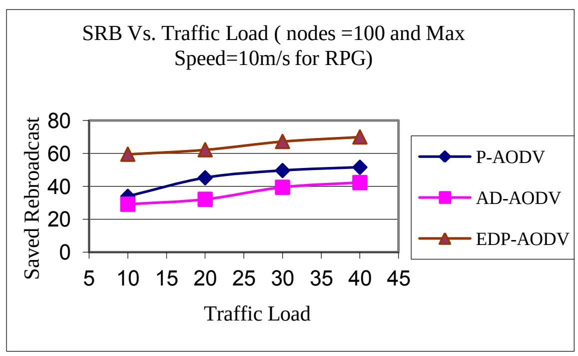

Figure 3. SRB Vs. Traffic loads for RPG

5.3 Collisions

We measure the number of collisions for these scenarios at the physical layer. Since control packets and data packets share the same physical channel, the collision probability is high when there are a large number of control packets.

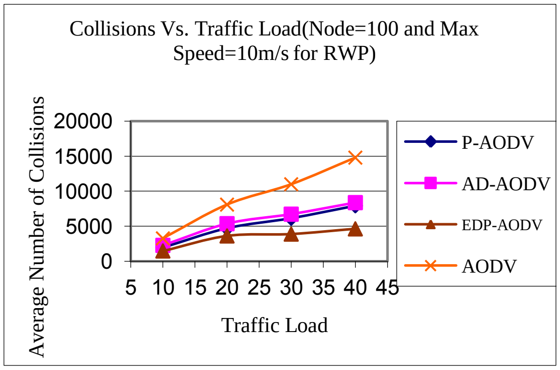

Figure 4. Collision vs. Traffic loads for RWP

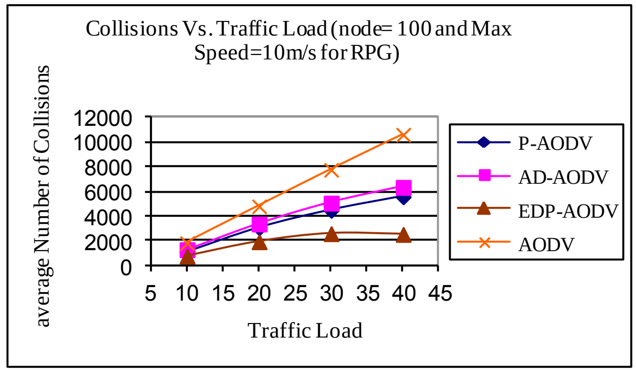

Figure 6. Collision Vs. Traffic loads for RPGM

Figs.4, 5 and 6 represent a comparison of collision between our algorithm (EDP-AODV), P-AODV, AD-AODV and Blind AODV under different mobility models.

As shown in the Fig4. (RWP scenario), our algorithm incurs fewer numbers of collisions than that of the P-AODV, AD-AODV and Blind AODV. Moreover, similar behaviour is observed for the scenario of the Manhattan mobility model (Fig.5). Our algorithm achieved less collision compared with the P-AODV, AD-AODV and Blind AODV algorithms.

Additionally, Fig.6 shows the collision of our algorithm, P-AODV, AD-AODV and Blind AODV under RPGM model. As shown in the figure, our algorithm has a lower collision than the P-AODV, AD-AODV and Blind AODV.

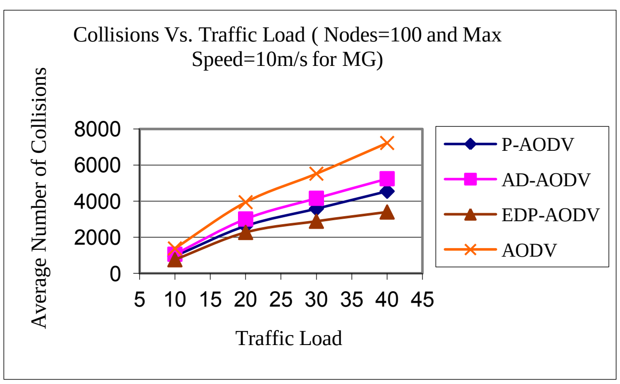

Figure 5. Collision Vs. Traffic loads for MG

5.4 Reachability

Reachability measures are the proportion of nodes which can receive a broadcast packet A host will miss a packet if all of its neighbours decide to suppress rebroadcasts.Within a network without separation, the flooding scheme guarantees that all nodes can get the broadcast packets at the expense of additional traffic caused by redundant rebroadcasts. In reality, however, redundant rebroadcasts also contribute to possibility of packet collisions that may eventually cause packet drops, thus adversely affecting the reachability.

We randomly choose source–destination node pairs and ensure if a packet can arrive at the destination node from the source node. If there is an existing route from the source node to the destination node, then the routing request packets broadcast from the source node have arrived at the destination node. We calculate the percentage of the node pairs that have a route between the source and the destination over the total number of selected pairs [3]. This ratio is not exactly equal to the reachability, but it is proportional to the reachability. We use this percentage to compare the reachability with different approaches.

Fig.7 shows the reachability for a network with 100 nodes, 10 m/s maximum speed and 10, 20, 30 and 40 connections of source-destination pairs, respectively for Random waypoint mobility model. The enhanced algorithm, adjusted probabilistic flooding [4,7], dynamic probabilistic flooding [13] and the simple AODV algorithms provide slightly similar reachability results at all

Traffic Load connections which are fallen between (93.41-95%).

Fig.8 shows the comparison between our algorithm and other algorithms in terms of reachability for the Manhattan Grid mobility scenario. As shown in the figure the reachability at all traffic load connections for all algorithms is slightly same.

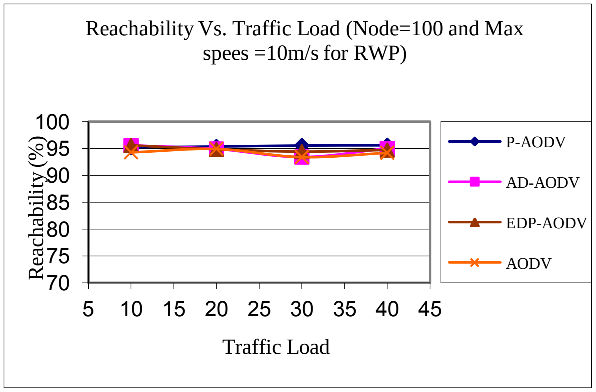

Figure 7 . Reachability Vs. Traffic load for the RWP

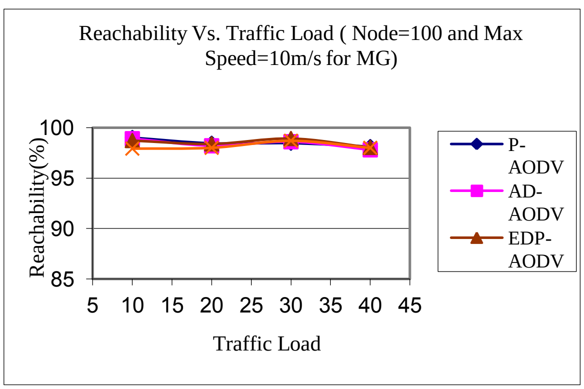

Figure 8. .Reachability Vs. Traffic load for the MG

Fig.9 also shows the comparison between our enhanced algorithm, adjusted probabilistic flooding [4,7], dynamic probabilistic flooding [13] and the simple AODV algorithms in terms of reachability for the Reference Point Group mobility scenario. As shown in the figure the reachability at all traffic load connections are fallen between (94.7-96.8%). Moreover the figure shows that dynamic probabilistic flooding [18] (P-AODV) slightly performs better reachability than other algorithms.

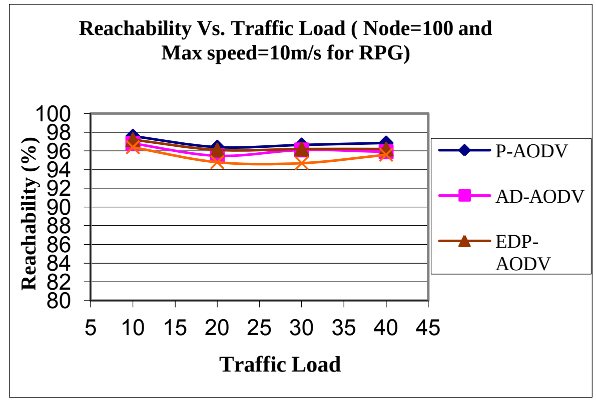

Figure 9. Reachability Vs. Traffic load for the RPG

6 CONCLUSIONS

This paper has evaluated the performance of enhanced probabilistic flooding on the AODV protocol where nodes move according to different mobility models, which traditional uses simple flooding, in order to increase the saved rebroadcast of rout requests. This proposed algorithm decides the rebroadcast probability by taking into account the network density. In order to improve the saved rebroadcasts, the rebroadcast probability of low density nodes is increased while that of high density of mobile nodes is decreased. Compared with P-AODV, AD-AODV and Blind AODV, our simulation results have shown that the proposed probabilistic flooding algorithm outperforms the P-AODV, AD-AODV and Blind AODV in terms of saved rebroadcast, even under conditions of different number of source-destination pair's connections and different mobility models. It also shows lower collision and generates less route request than the P-AODV, AD-AODV and Blind 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 protocol (DSR) with different mobility models representing more realistic scenarios.

We also plan to make an analytic model for our proposed algorithm in order to compare it with simulation results.

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