Improving Route Discovery of Dynamic Probabilistic Flooding in On-Demand Routing Protocols for MANETs

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***Abstract*— In mobile ad hoc networks (MANET), broadcasting is widely used in route discovery and many other network services. The efficiency of broadcasting protocol can affect the performance of the entire network. As such, the simple flooding algorithm aggravates a high number of unnecessary packet rebroadcasts, causing contention and packet collisions. Proper use of probabilistic method can reduce the number of rebroadcasting, therefore reduce the chance of contention and collision among neighboring nodes. A good probabilistic broadcast protocol can achieve high save rebroadcast and low collision. In this paper, we propose a dynamic probabilistic approach when nodes move according to way point mobility and compare it with simple flooding AODV and fixed probabilistic scheme. Our approach dynamically set the rebroadcasting probability according to the number of nieghbors nodes distributed in the ad hoc network. Simulation results show our approach performs better than both simple flooding and fixed probabilistic flooding.**

***Keywords*—AODV, MANETs, probabilistic broadcasting, reachability**

I. Introduction

Mobile ad hoc networks (MANETs) are self-organizing mobile wireless networks that do not rely on a preexisting infrastructure to communicate. Network-wide dissemination is used widely in MANETs [1] for the process of route invention, address resolution, and other network layer tasks. For example, on demand routing protocols such as ad-hoc on demand distance vector (AODV) [8] and dynamic source routing (DSR) [12] use the broadcast information in route request packets to construct routing tables at every mobile node [3]. 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*" [2].

In this paper, we propose a dynamic probabilistic approach for broadcast. We set the rebroadcast probability of a host according to number of neighbor nodes information.

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

Simulation results show that broadcast redundancy can be significantly reduced through the proposed approach.

The rest of this paper is structured as follows. *Section 2* includes the background and related work of dissemination in MANETs. *Section 3* presents the proposed dynamic probabilistic approach, highlighting its distinctive features from the other similar techniques. The parameters used in the experiments and the performance results and analysis to evaluate the effectiveness and limitation of the proposed technique are presented in *Section 4*. *Section 5* concludes the paper and outlines the future work.

II. Related Work

This section analyses the related work which directly or indirectly aims at reducing the number of broadcast packets generated by the flooding algorithm. The high number of redundant broadcast packets due to flooding in MANETs has been referred to as the "Broadcast Storm Problem" [2].

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, when receiving a broadcast message for the first time, a host rebroadcasts the message with a fixed probability *P*. The counter-based scheme inhibits the rebroadcast if the message has already been received for more than *C* times. In the distance-based scheme a node rebroadcasts the message only if the distance between the sender 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 certain pre-fixed bound. In the location-based scheme, the additional coverage idea [2] is used to make a decision whether to rebroadcast a packet. Additional coverage is achieved by the locations of broadcasting nodes using the geographical information of a MANET [6].

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 [2].

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 [1].

Zhang and Dharma [3] have also described a dynamic probabilistic scheme, which uses a combination of probabilistic and counter-based schemes. The value of a packet counter does not necessarily correspond to the exact number of neighbors from the current host, since some of its neighbors 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. [4,7] have proposed fixed pair of probabilistic broadcast scheme where the forwarding probability *p* is adjusted by the local topology information. Topology information is obtained by proactive exchange of "HELLO" packets between neighbors. For both approaches presented in [3] and [4] there is an extra overhead i.e., before calculating the probability, average number of neighbor nodes should be known in advance.

III. Dynamic Probabilistic Broadcasting Algorithms

As studied earlier, traditional flooding suffers from the problem of redundant message reception. The same message is received multiple times by every node, which is inefficient, wastes valuable resources and can cause high contention in the transmission medium. In fixed probabilistic flooding the rebroadcast probability *p* is fixed for every node. This scheme 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. Our algorithm dynamically calculates the value of rebroadcast probability "*P*". Higher value of "*P*" means higher number of redundant rebroadcast while smaller value of "*P*" means lower reachability.

Where P_{max}=0.9 and P_{min}=0.4

A concise sketch of the dynamic probabilistic flooding algorithm is shown in Algorithm and works as follows. On hearing a broadcast packet (pkt) at host node *i* for the first time, the node rebroadcasts a message according to a calculated probability with the help of neigbour nodes of i, Therefore, if node i has a high probability *p*, retransmission should be likely, Otherwise, if i has a low probability *p* retransmission may be unlikely.

Algorithm: Dynamic probabilistic broadcasting algorithms

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

Input Parameters:

$pkt(i)$: Packet to relay by ith node.

$\mathrm{P}(i)$: Rebroadcast probability of packet *(pkt)* of ith node.

$RN(i)$: Random No. over [0,1] for ith node to compare with the rebroadcast probability *P*.

$S_{nbr}\ (i)$: Size/No of neighbour nodes of ith node.

Output Parameters:

$Discpkt(i)$: Packet *(pkt)* will be discarded for node(i), if it is in the packet list of ith node.

$Rbdpkt(i)$: Packet *(pkt)* will be rebroadcasted by ith node, if probability *P* is high.

$Drpkt(i)$: Packet *(pkt)* will be dropped by ith node, if probability *P* is low.

DPFlood(msg): Dynamic Probabilistic Flooding

1: Upon reception of packet *(pkt)* at node (i)
2: **if** packet *(pkt)* received for the 1^{st} time **then**
3: Go to **Procedure (1)**
4: Relay the packet *(pkt) when* (P> $RN(i)$)
5: **else**
6: Drop *pkt*
7: **endif**

Procedure (1)

This procedure calculates the Rebroadcast Probability *P* of ith node

Input Parameters:

$S_{nbr}\ (i)$: Size/No. of neighbour nodes of ith node.

Output Parameters:

$\mathrm{P}(i)$: Rebroadcast probability of packet *(pkt)* of ith node.
Probability (S_{nbr}(i)): Rebroadcast Probability for ith node

Set *P*: = 1

Go to **Procedure (2)**

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

if $\mathrm{P} < \mathrm{P}_{\min}$ **then**

$\mathrm{P} = \mathrm{P}_{\min}$

endif

return (*P*)

<u>Procedure (2)</u>

This procedure calculates the size/No. of neighbour nodes of ith node

Input Parameters:

$nbrTable(i)$: Neighbour table for ith node.

Output Parameters:

$S_{nbr}\ (i)$: Size/No. of neighbour nodes of ith node.

NBRsize(nbrTable): Size of the neighbour nodes

if nbrTable->size = = null **then**

return (o)

else

return (nbrTable->size)

endif

The proposed algorithm dynamically adjusts the rebroadcast probability *p* at each mobile host according to the number of neighbor nodes. The value of *p* is different in different areas. In a sparser area, the rebroadcast probability is large whilst in the denser area, the probability is low. Compared with the probabilistic approach where *p* is fixed and with the simple flooding approaches, the proposed algorithm achieves higher saved rebroadcast and lower collision.

IV. Performance Analyses

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

A. Simulation Setup

We have used the GloMoSim network simulator (version 2.03) [9] to conduct extensive experiments to evaluate behaviour 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 [8,10,11] 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 1000m × 1000m area with random waypoint model of 80 mobile hosts. The network bandwidth is 2 Mbps and the medium access control (MAC) layer protocol is IEEE 802.11[3]. Other simulation parameters are shown in Table 1.

In our simulation, each node initially selects a random movement start time, direction, and distance. After it travels the specified distance along the predefined direction, it will stay there for a random pause time, and then start another round of movements. We study the performance of the broadcast approaches in these scenarios.

B. 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).

Fig.1 shows that our improved algorithm can significantly reduce the saved rebroadcast (SRB) for network with 80 nodes, different mobility speed and 10 source-destination pair's connections.

TABLE1. SIMULATION PARAMETERS

Simulation Parameter	Value
Simulator	GloMoSim v2.03
Network Range	1000m×1000m
Transmission Range	250m
Mobile Nodes	80 and 100
Traffic Generator	Telnet
Band Width	2Mbps
Packet size	512Bytes
Packet Rate	10 pps
Simulation time	900s

Fig.2 shows the relationship between the number of relays and the mobility of a network with 80 nodes and 10 source–destination pairs. 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

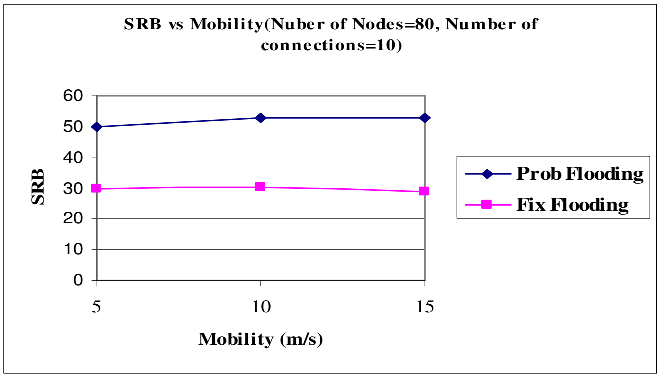

Fig.1 SRB vs. Mobility

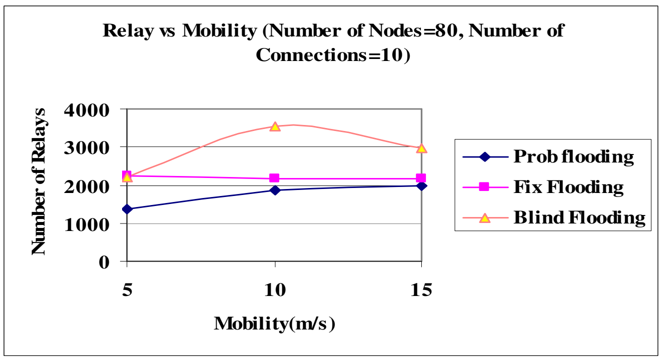

Fig.2 Relay vs. Mobility

transmission of route request packets. As shown in Fig.2 our approach has lower relays numbers than FP-AODV and blind flooding.

C. *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.

Fig. 3 shows our algorithms incur fewer collisions than that of simple AODV and FP-AODV.

V. Conclusion

In this paper we propose a dynamic probabilistic broadcasting scheme for mobile ad hoc networks where nodes move according to way point mobility model [13]. The proposed approach dynamically sets the value of the rebroadcast probability for every host node according to the neighbor's information. Our simulation results prove this approach can generate less rebroadcasts than that of the fixed probabilistic approach, while keeping the reachability high. It also demonstrates lower collisions than all the presented approaches.

For future work it would be interesting to explore the algorithm for different mobility models in mobile ad-hoc

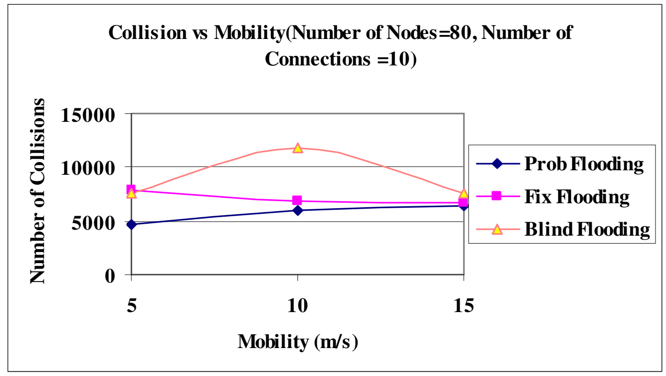

Fig.3 Collision vs. Mobility

network using neighbours information. We also plan to evaluate the Performance of dynamic probabilistic flooding on the Dynamic Source Routing (DSR) with different mobility models representing more realistic scenarios.

References

[1] J. Cartigny and D. Simplot. Border node retransmission based probabilistic broadcast protocols in ad-hoc networks. *Telecommunication Systems*, 22(1-4):189–204, 2003.

[2] Y.-C. Tseng, S.-Y. Ni, Y.-S. Chen, and J.-P. Sheu. The broadcast storm problem in a mobile ad hoc network. *Wireless Networks*, 8(2/3):153–167, 2002.

[3] Q. Zhang and D. Agrawal. Dynamic probabilistic broadcasting in manets. *Journal of ParallelDistributed Computing*, 65:220–233, 2005.

[4] Yassein, M. B., M. O. Khaoua, et al. (2006). Improving route discovery in on-demand routing protocols using local topology information in MANETs. Proceedings of the ACM international workshop on Performance monitoring, measurement, and evaluation of heterogeneous wireless and wired networks. Terromolinos, Spain, ACM Press.

[5] Stefan, P., B. Mahesh, et al. (2006). MISTRAL: efficient flooding in mobile ad-hoc networks. Proceedings of the seventh ACM international symposium on Mobile ad hoc networking and computing. Florence, Italy, ACM Press.

[6] B. Williams, T. Camp, Comparison of broadcasting techniques for mobile ad hoc networks.*Proc. ACM Symposium on Mobile Ad Hoc Networking & Computing* (*MOBIHOC 2002*), pp.194–205, 2002.

[7] L. M. M. M. Bani-Yassein, M. Ould-Khaoua and S. Papanastasiou. Performance analysis of adjusted probabilistic broadcasting in mobile ad hoc networks. *International Journal of Wireless Information Networks*, pages 1–14, March 2006. Springer Netherlands.

[8] C.E. Perkins, E.M. Royer, Ad-hoc on-demand distance vector routing, in: Proceedings of the 1999 Second IEEE Workshop on Mobile Computing Systems and Applications, IEEE Computer Society, New York, February1999, pp. 90–100.

[9] X. Zeng, R. Bagrodia, M. Gerla, GloMoSim: a library for parallel simulation of large-scale wireless networks, in: Proceedings of the 1998 12th Workshop on Parallel and Distributed Simulations. PADS '98, May26–29, Banff, Alb., Canada, 1998, pp. 154–161.

[10] Y. Sasson, D. Cavin, A. Schiper, Probabilistic broadcast for flooding in wireless mobile ad hoc networks, *Proc. IEEE Wireless Communications & Networking Conference* (*WCNC* 2003), pp. 1124-1130, March 2003.

[11] Y. Sasson, D. Cavin, A. Schiper, Probabilistic broadcast for flooding in wireless mobile ad hoc networks, EPFL Technical Report IC/2002/54, Swiss Federal Institute of Technology(EPFL), 2002.

[12] D.B. Johnson, D.A. Maltz, Dynamic source routing in ad hoc wireless networks, in: T. Imielinski, H. Korth (Eds.), Mobile Computing, Academic Publishers, New York, 1996, pp. 153–181

[13] Camp, T., Boleng, J. and Davies, V. (2002). A survey of mobility models for ad hoc network research. Wireless Communications & Mobile Computing (WCMC): Special Issue on Mobile Ad Hoc Networking: Research, Trends, and Applications, vol. 2, no. 5, 483–502.