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The Dynamic Implementation of Broadcasting in MANETS

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Abstract—Broadcasting has a central importance to Mobile Ad hoc Networks (MANETs) wherein it is frequently executed for the route discovery, address resolution, the application of paging a host and many other network services. Use of simple flooding, for broadcasts, causes redundant rebroadcasts and contention and collision issues that may lead to what is known as the broadcast storm problem. In this paper, we propose an angle-aware broadcasting algorithm as a contribution to address the broadcast storm problem. In this algorithm, rebroadcast probability is dynamically calculated, based on the angles covered (cover angles) by a node with respect to its neighbors, without using the latter's knowledge information or any complex calculations thereof. A simulation based execution of the proposed algorithm and performance comparison with flooding and fixed probabilistic broadcasting schemes show that our angle-aware probabilistic broadcasting technique outperforms the other two, in term of both delivery ratio and number of retransmissions.

Key words: Broadcasting • probabilistic • angle aware • simulation • routing

I. INTRODUCTION

Mobile Ad Hoc Networks (MANETs) are special class of networks where nodes communicate among themselves in an infrastructure-less environment. MANETs can be used in a variety of application domains like health, military, tracking and surveillance. Broadcasting is one of the preliminary techniques for information dissemination and an enabling tool for many routing protocols in MANETs [1]. For example, in Adhoc on Demand Distance Vector (AODV) [17] a node typically uses broadcasting for route request, in directed diffusion [15] a sink node broadcasts its interest to request data and in rumor routing [16] events are broadcasted instead of queries. The radio power and channel utilization of MANET nodes are restricted by energy constraints and regulatory authorities, prohibiting nodes to send data directly to the destination. Therefore, nodes send their data to the destination in a multi-hop fashion.

The simplest approach to disseminate information among neighbors is to flood the data, in order to propagate information, by broadcasting it. Excessive flooding may, however, lead to the broadcast storm problems, like redundancy, contention and collision [12]. Blind flooding may result in problems, like implosion, overlap and resource blindness. Implosion refers to a situation where duplicate messages are sent to same node while overlap occurs when two sensor nodes close to each other and report some factor, e.g. temperature of that area. Resource blindness, in contrast, is that state of not being able to consider the resources, e.g. remaining energy, of some node(s) [13]. Flooding, though simple to operate, results in a large routing overhead, wasting channel capacity, resources and energy. A large chunk of the research, in the concerned area, is dedicated to the reduction in the number of transmissions to reduce contentions and collisions and enhance channel utilization as well as network throughput. Many broadcasting-based approaches [5-8] have been proposed for MANETs and most of these produce sub-optimal results [19]. Simple probability based approaches use pre -defined fixed probability to determine if a node should rebroadcast a packet or not. Setting this rebroadcast probability is one of the major challenges in such approaches. Although some researchers argue that an optimal predefined rebroadcast probability can be determined [7, 8] this can only be true for specific network conditions. It is, therefore, always expedient to set the rebroadcast probability dynamically on the basis of specific network conditions [19]. We propose a dynamic angle aware probabilistic broadcasting algorithm which set the forwarding probability of a node based on the cover angle of a node with respect to its neighbors. If the covered angle is a small, the node has high retransmission probability; otherwise, the packet retransmission probability is low. In the proposed scheme, the position of the sender and a node itself can be estimated by the Global Positional System (GPS) or any other localization technique based on the angle of arrival, triangulation or signal strength indicators. In order to prove the effectiveness of our scheme, a simulation based comparison has been carried out against the fixed probability-based broadcasting and simple flooding approaches under various network conditions. The rest of the paper is organized as follows. In Section 2, we introduce the background and related work of broadcasting in MANETs. Section 3 describes our approach of covered angle based probabilistic broadcasting with special emphasis on its peculiarity with respect to other similar approaches. An NS-2 based simulation of our approach is being executed in Section 4 which presents the simulation results and compares the performance of our scheme with flooding and fixed probabilistic approaches. Section 5 concludes the paper.

II. Related Work

Unlike cellular and traditional wired networks, adhoc networks are infrastructure less. In the early work on MANET routing protocols, the contemporary approaches for traditional wired networks were applied. These approaches do not perform well as their design was primarily motivated by wired networks without considering the node mobility. In addition, a packet loss was assumed to be solely the result of congestion. One of the earliest and the classical way of broadcasting in MANETs is flooding. But blind execution of flooding may results in broadcast storm. It is experimentally shown in [4] that rebroadcasts in flooding results in large overheads and should be avoided. Gossiping is an improved form of flooding that tries to overcome implosion by selecting neighbors on the basis of some fixed probabilities [14]. The problem of implosion is, however, mitigated at the cost of reliability [22] increased delays and abnormal resource utilization. Dynamic gossiping [22] computes rebroadcast probability of neighboring node on the basis of local node density. The scheme works well in dense networks, while performing poorly in sparse ones.

The authors in [4] classified broadcasting into five different categories, discussed in the following lines. In the probabilistic approach (for instance [24]), packets are forwarded based on certain probabilities. Probabilistic approaches exhibit the reachability problem outlined in [4]. The counter-based approach rebroadcasts packets based on the number of times it has received copy of a specific packet in certain random time interval. In the distance based approach, relative distance between the sender and receiver decides to broadcast or otherwise; broadcast only if the distance between sender and receiver is larger than certain threshold. The distance based schemes enhance reachability at the cost of larger number of rebroadcast messages [21]. Location based schemes use spatial information of the sending node, relaying node and the destination. In cluster based schemes clusters are created and each cluster is governed by a cluster head. Cluster head is responsible for the rebroadcast of a given packet and it is selected in such a way that it can reach all the nodes within that cluster. Various hybrid approaches have also been proposed in the literature. Distance based and counter based approaches are combined in DISCOUNT [20]. DISCOUNT enhances the reach ability as well as the rebroadcast efficiency and selects the counter threshold dynamically. The two approaches are also combined in [9] but the problem is that the packet counter may not portray the correct picture, since some of the neighbors may not rebroadcast because of the local rebroadcast probability. Moreover, random time interval, of the said scheme, may result in increased end to end delay [23]. Probabilistic and distance based approaches are combined in [21] which claims to exploit the benefits of both the algorithms. A combination of the probabilistic and knowledge based approach c the one hop neighborhood information-is presented in [23]. In all the approaches discussed above, flooding is the simplest but the most expensive one in terms of redundant rebroadcasts. The probabilistic approaches minimize the number of rebroadcasts but may suffer as far as reachability is concerned. Although counter-based approaches are good in terms of throughput and reachability, they may lead to increased latency. The neighbor-knowledge-based schemes are handicapped by the increased overheads due to the requirement of exchanging the neighborhood data among the underlying hosts. The distance-based scheme may cover a large part of the network but they need a large number of broadcast messages to do so.

III. COVER ANGLE-BASED PROBABILISTIC BROADCASTING

We propose an angle-aware probabilistic broadcasting scheme to yield higher performance in term of delivery ratio and number of retransmitting nodes. In addition, it is simple enough for easy implementation without the use of neighbor's information or maintaining a counter for duplicate packets. We describe the details of our approach below.

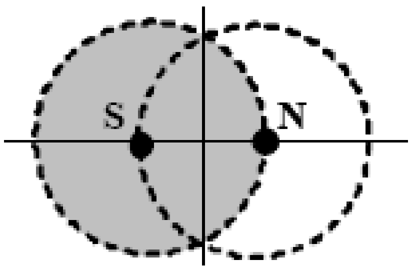


Fig. 1a: Area covered by a node

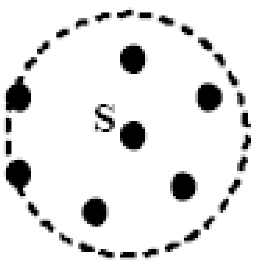


Fig. 1b: Coverage disk of a node

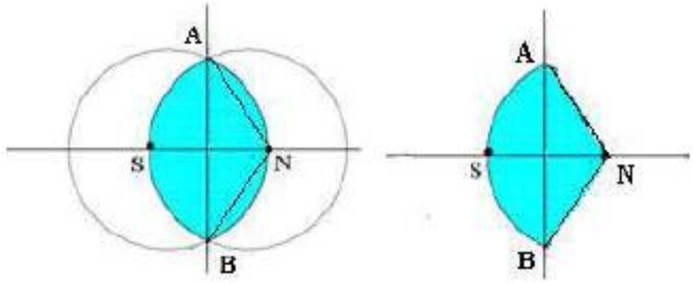


Fig. 2: Example angle covered of a node

Definitions

Def 1: Coverage disk of a node. The coverage disk of node S, denoted by d(s), is a disk that is centered at S and whose radius is the transmission range of S, as shown in Fig. 1b.

Def 2: Area Covered by a node. The area covered by disk of nodes A= {N, S} (which includes sender N and receiver S), denoted by C(A), is the intersection of coverage disks of nodes in A, as shown in Fig. 1a.

Def 3: Angle covered on disk d(N).Let A and B be the point of intersection of disk d(N) and disk d(S) then angle ANB is the angle covered on disk d(N). This is called the covered angle of node N.

When a node S receives a message m from its neighbor N, at a distance equal to the transmission radius, then the angular distance is 120° and area covered by this angle is 0.39pr2 [4]. In the Fig. 3, let us assume that node S receives a message m from its neighbor N which is at a distance exactly equal to the transmission radius of S. Thus the cover angle of S covered by the transmission of its neighbor N is 120º. Assume a unit disc model where all the nodes have the same transmission radius. For instance, if S receives the same message m from a number of its neighbors, as shown in Fig. 3. and if the sum of the disjoint cover angles is 360º then the

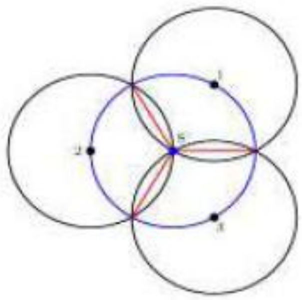


Fig. 3: Example cover angle

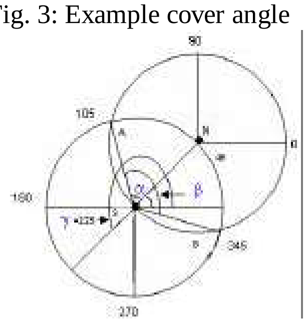


Fig. 4: Cover angle estimation

broadcasting area of S has been completely covered by its neighbors and eventually its rebroadcast probability should be zero, i.e. p = 0.Based on the above discussion, we propose a cover angle-based probabilistic broadcasting approach where a node takes the rebroadcast decision on a probability value that is dynamically calculated using the cover angle concept, unlike simple flooding where p = 1 or the fixed probabilistic broadcasting where a fixed value of p is predefined for every node. The objective of our scheme is to minimize the number of transmissions and at the same time improve reliability and packet delivery ratio. Following are the components of our scheme.

Distance estimation: When a sender sends a flooded packet, it supplies its position information to the receiver. The receiver then extracts this information from the sender's header of the packet. Let N(xN, yN) be the position coordinates of the sender and S(xS yS) bethe position coordinates of receiver. Let δ be the Euclidean distance between sender N and receiver Sthen:

$$\delta = \|N-S\| = \sqrt{(x_N - x_S)^2 + (y_N - y_S)^2} \quad (1)$$

Angle estimation

Cover angle: Before receiving any packet, a node has a cover angle equal to 360° but when any packet is received by this node, the cover angle is set to some inferior value, as explained above. If the direction of the incoming packet is not known then it is not possible to determine from where and how much cover angle has been covered, as is the case with the counter based schemes. When a node receives a packet, it calculates its angle from the sender of the packet using its own position and the position information of the sender, by employing Eq. 2:

$$\tan\varphi = \frac{y_N - y_S}{x_N - x_S} \quad (2)$$

Assume that all nodes have the same transmission line then we can easily estimate the angle position γ of receiver with respect to sender angle as follows.

$$\gamma = \begin{cases} \theta + 180 & \text{if } \theta < 180 \\ \theta - 180 & \text{if } \theta > 180 \end{cases} \quad (3)$$

where θ is the sender's angle. For instance, in Fig. 4, S receive a packet from its neighbor N through an angle of 45° then γ = 225°. Consider the triangle ASN shown in Fig. 4. The lengths of the sides of this triangle are δ, rN and rS Let K be the area of the triangle Δ ASN.We get the area of the triangle as follows:

$$K = (1/4)\sqrt{((r_N+r_S)^2-\delta^2)(\delta^2-(r_N-r_S)^2)} \quad (4)$$

Let A(xA, yA) and B(xB, yB) are the two intersection points where N's transmission intersects with that of S, then the coordinates of A and B can be estimated as follows:

$$x_A = (1/2)(x_N+x_S) + (1/2)(x_N-x_S)(r_S^2-r_N^2)/\delta^2+2(y_N-y_S)K/\delta^2 \quad (5)$$

$$y_A = (1/2)(y_N+y_S) + (1/2)(y_N-y_S)(r_S^2-r_N^2)/\delta^2-2(x_N-x_S)K/\delta^2 \quad (6)$$

$$x_B = (1/2)(x_B+x_A) + (1/2)(x_B-x_A)(r_A^2-r_B^2)/\delta^2-2(y_B-y_A)K/\delta^2 \quad (7)$$

$$y_B = (1/2)(y_B+y_A) + (1/2)(y_B-y_A)(r_A^2-r_B^2)/\delta^2+2(x_B-x_A)K/\delta^2 \quad (8)$$

Assuming all the nodes to have the same transmission radius r, i.e. r = rN, = rS, we have from the above equation:

$$x_A = (1/2)(x_N+x_S) + 2(y_N-y_S)K/\delta^2 \quad (9)$$

$$y_A = (1/2)(y_N+y_S)-2(x_N-x_S)K/\delta^2 \quad (10)$$

$$x_B = (1/2)(x_N+x_S)-2(y_N-y_S)K/\delta^2 \quad (11)$$

$$y_B = (1/2)(y_N+y_S) + 2(x_N-x_S)K/\delta^2 \quad (12)$$

Let α represent ∠ASN in degrees then:

$$\alpha = \tan^{-1}\left(\frac{m_1 - m_2}{1 + m_1 m_2}\right) \quad (13)$$

Where

$$m_1 = \left(\frac{y_N - y_S}{x_S - x_S}\right) \text{ and } m_2 = \left(\frac{y_S - y_A}{x_S - x_A}\right)$$

Let β represent ∠ASB, which is the double angle of ∠ASN then

$$\beta = 2\angle ASN = 2\alpha \quad (14)$$

Now from equation (3) and (13) the cover angle can be calculate as:

$$\text{Cover angle } (c_1, c_2) = ((\gamma-\alpha), (\gamma+\alpha))$$

where c1 and c2 are the end points of the angle covered by the message m transmission.

Cover angle-based probabilistic algorithm: As discussed earlier, pre-fixed rebroadcast probability always results in degraded performance as network dynamics are vary considerably due to the node mobility and wireless channel characteristics. It is thus wiser to set the rebroadcast probability dynamically based on the current network conditions which may alter as function of network density, node degree and channel quality [7, 8]. The angle-aware dynamic probabilistic broadcasting approach, proposed in this work, uses the cover angle concept to calculate the rebroadcast probability of a given node dynamically. A brief outline of the algorithm is presented in algorithm-1 and operates as follows. Assume a node X receiving a new broadcast message m. X stores m in the received packet list called

RCV_LIST and starts delay timer t. If X receives another copy of m before t expires, it is again stored in the RCV_LIST. When t expires, X estimates the cover angle for each incoming message, sums up the non overlapping cover angles and calculate probability for rebroadcast decision based on these calculations. Assume Y is a neighbor of X. If the maximum cover angle of X is covered by Y, the rebroadcast probability of X is kept low.

Algorithm 1:Location-based Dynamic Probabilistic Broadcasting Algorithm

1: **if** m is a new message **then**
2: Start delay timer t
3: Store position (x1, y1) of m in RCV_LIST
4: **else if** m is a duplicate message **then**.
5: REPEAT step 3.
6: **end if**
7: After delay time t expires
8: Set CURR_RCV←First record of RCV_LIST.
9: **while** (CURR_RCV != NULL) **do**
10: dx = x2-x1, dy = y2-y1
11: Compute distance δ using Eq (1)
12: Compute γ using Eq (3)
13: **if** (γ < 0) **then** γ = (γ + 360)
13: Compute α using Eq (13)
14: c1 = (γ –α), c2 = (γ + α)
15: **if** (c1 = o and c2 <= 360) **then**
16: add [(c1, 0), (c2, 1)] to the CA_LIST
17: **else if** (c1 < 0) **then**
18: add [(0, 0), (c2, 1)] and [(360+c1, 0), (360, 1)]
19: **else if** (c2 > 360) **then**
20: add [(0, 0), (c2-360, 1)] and [(c1, 0), (360, 1)]
21: **end if**
22: CURR_RCV←CURR_RCV–>next
23: **end while**
24: SORT CA_LIST with angle
25: Initialize INTERVEL_DEPTH = 0
26: Set CURR_REC←First record of CA_LIST
27: **while** (CURR_ REC != NULL) **do**
28: **if** (CURR_REC–>type = = 0) **then**
29: increase INTERVAL_DEPTH by 1.
30: **if** (INTERVAL_DEPTH > 1) **then**
31: remove CURR_REC
32: **else**
33: CURR_REC←CURR_REC–>next
34: **end if**
35: **else if** (CURR_REC–>type = = 1) **then**
36: decrease INTERVAL_DEPTH by 1.
37: **if** (INTERVAL_DEPTH > 0) **then**
38: remove CURR_REC
39: **else**
40: CURR_REC←CURR_REC–>next
41: **end if**
42: **end if**
43: **end while**
44: Set sum of cover angle θ = 0
45: Set CURR_REC←First record of CA_LIST.
46: **While** (CURR_REC != NULL) do
47: Set c1 = CURR_REC –>angle
48: CURR_REC = CURR_REC –>next
49: Set c2 = CURR_REC –>angle
50: CURR_REC = CURR_REC –>next
51: $\theta = \theta + (c2-c1)$
52: **end while**
53: Compute forwarding probability
Where θ is sum of cover angle

generate a random number r = rand (0, 1)
if (r < p) then
cancel retransmission
else
rebroadcast **end if**

IV. Performance Evaluation

Simulation description: A Simulation study has been carried out over the network simulator NS-2 [14] with the Monarch project extension [24]. The simulation parameters are listed in Table 1. Each simulation is run ten times to achieve a confidence interval of 90%. The first set of performance tests included varying network size at a nearly constant network density followed by the performance was evaluated against a varying network density with a fixed-size area. The last set of tests includes the study of all schemes with varying packet sending rates. We evaluated our Cover angle-based probabilistic broadcasting (CP) against Plain flooding (PL) and the Fixed Probabilistic (FP) broadcasting. For the latter scheme, we set the value of P = 0.65, as had been done in [4].

Performance metrics: The authors in [4, 6] have presented a variety of performance metrics for broadcast protocols. In this work, we use number of retransmitting nodes, delivery ratio and average end to end delay. All these are complementary measures and the formal definitions of these three metrics are given as follows [4].

Number of retransmitting nodes: It can be defined by (nr-nt/nr) where nr is the number of hosts receiving the broadcast message and nt is the number of hosts that actually transmit the message. **Delivery ratio:** It is defined as nr/(n0-1) where n0 is the total number of hosts in the network.

Average end to end delay (d): The average delay from source node to each receiving node can be described by the following equation:

Table 1: Fixed simulation parameters

Parameters	Values
Simulator	NS-2(version 2.29)
Transmission range	100 meters
MAC layer	IEEE 802.11(no RTS/CTS/ACK)
Data packet size	64 bytes
Bandwidth	2 Mb/s
Simulation time	100 seconds
Number of trails	10
Mobility model	Random way point
Radio propagation model	Two-ray ground reflection model
Speed variation	Uniform (0, max)
Packet sending rate	10 packets/simulation second
Confidence Interval	90 %

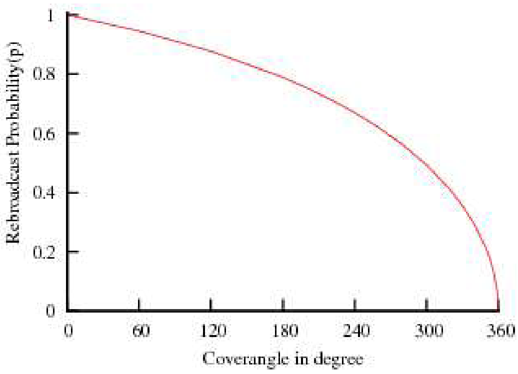


Fig. 6: Coverangle vs. probability

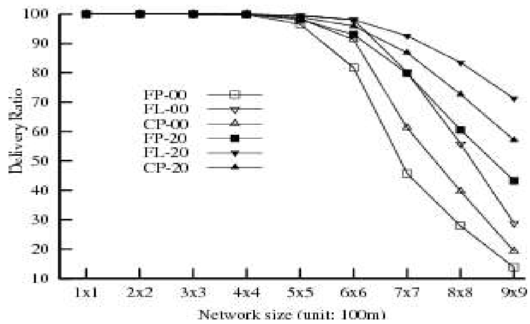


Fig. 7: Network size Vs delivery ratio in static and dynamic network

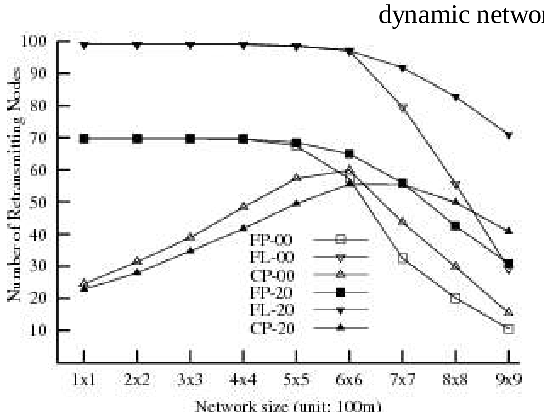


Fig. 8: Network size vs number of retransmitting nodes in static and dynamic network

Effect of network size and mobility on performance:

In this simulation the host number is set to 100. The simulation map varies from 1×1 to 9×9 square units; the unit length is equal to the radio propagation range. In the mobility model, the minimum speed for the simulation is 0m/s while the maximum speed is set as 20m/s. We set the pause time 0 second to test mobility adaptability. Note the last number in the legend indicates the maximum speed of the nodes i.e. 20 means a maximum speed of 20m/s. Figure 7 shows the performance of delivery ratio against different network sizes with respect to node density and mobility. It illustrates that in dense network Fig. 8: Network size vs number of retransmitting nodes in static and dynamic network i.e. 1×1 to 5×5 all broadcasting schemes have 100% delivery ratio but with the increase of the network size, the delivery ratio of all schemes decreases because there are not enough number of nodes to retransmit the message. The delivery ratio of our scheme is better than fixed probabilistic scheme. There are only slight difference in delivery ratio's between our scheme and flooding. The figure shows that in any broadcasting scheme, delivery ratios are higher in dynamic networks than that of static networks. Figure 8 shows the performance of saved rebroadcasts (Number of retransmitting nodes) of all broadcasting schemes as the network size increased. It shows that in dense network fixed probabilistic scheme save only 30% retransmission while our cover angle based probabilistic scheme save 42% to 78% retransmissions. In sparse network i.e. when the network size grows from 5×5 it seems that all schemes save more retransmission but the reason is that some nodes could not get the broadcast message. The figure shows that there is no effect of mobility on the performance of FP scheme but mobility improves the performance of our CP scheme. Figure 9 gives the end to end delay of the broadcasting schemes in different cases. It shows that the delay increases as the simulation area increases. The FP scheme has the best delay performance in all scenarios because maximum delay in FP is 10ms while it is 60ms in CP. The maximum delay in FL is also 10ms even then it suffers from longer delays because of many collisions. The end to end delay of our scheme is better or close to flooding in all cases. It shows that end to end delay performance is better in dynamic network than static network.

Effect of host density and mobility on performance:

Simulation parameters are the same as those used in the

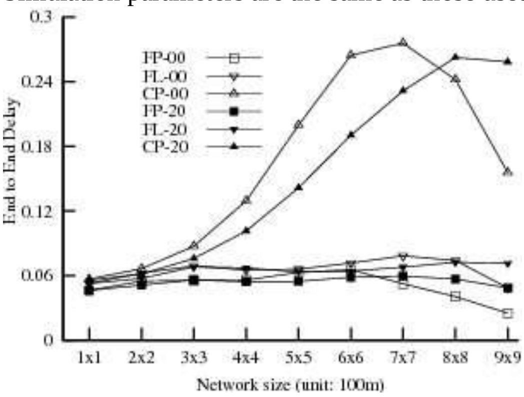


Fig. 9: Network size Vs end to end delay in static and dynamic network

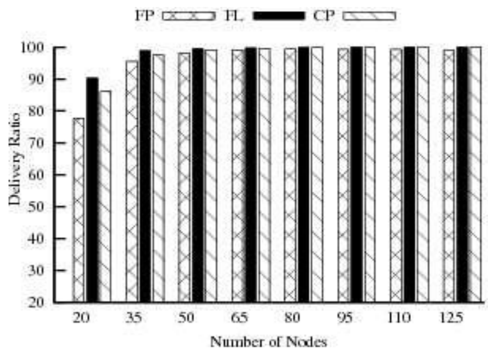


Fig. 10: Host density vs delivery ratio in static network i.e. mobility speed = 0m/s

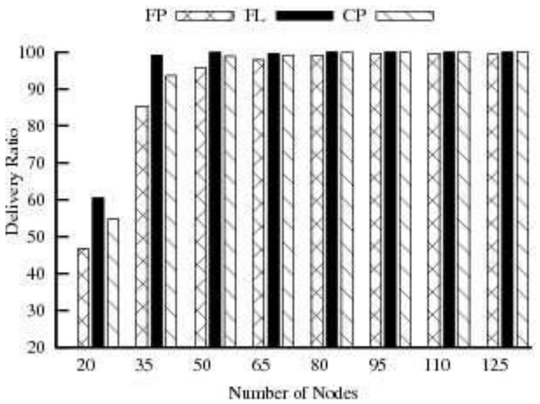


Fig. 11: Host density vs delivery ratio in dynamic network i.e. mobility speed = 20m/s

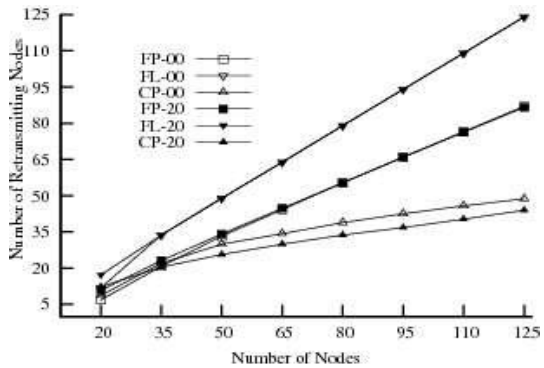
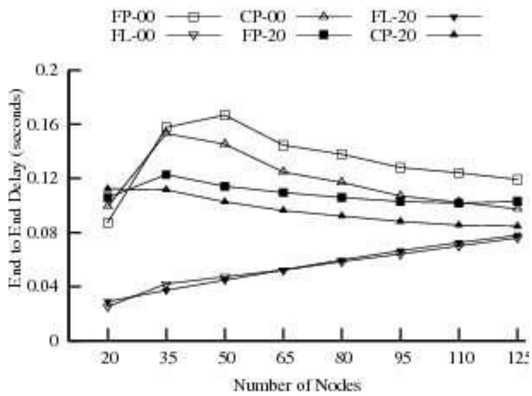


Fig.12: Host density vs. number of retransmitting nodes in static and dynamic network

probability of a node, if it has lower cover angle than its neighbor's, is set higher, otherwise it is set lower. Figure 12 shows the number of retransmitting nodes to transmit broadcast message without mobility and at the host mobility of

20m/s. As can be seen, our approach can substantially reduce the number of rebroadcasts than other approaches. This indicates that our approach is the most efficient among the four algorithms. The figure also shows that mobility does not affect the performance of flooding and fixed probabilistic schemes, but improve the retransmission performance of our CA scheme. Figure 12 shows the number of retransmitting nodes to transmit broadcast message without mobility and a host mobility of 20m/sec. As shown in Fig. 8, our approach can substantially reduce the number of rebroadcasts than other approaches. This indicates that our approach is the most efficient among the four algorithms. The figure also shows that mobility does not affect the performance of flooding and fixed



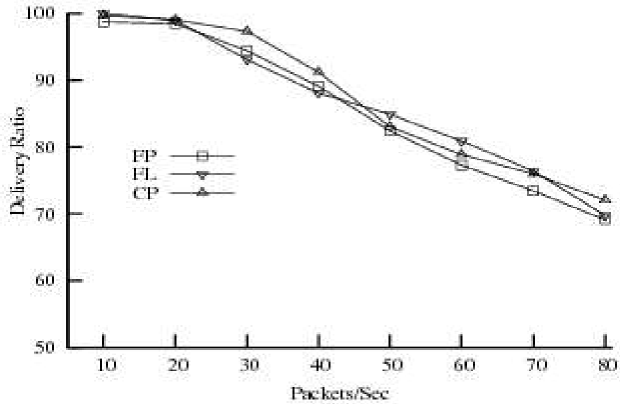
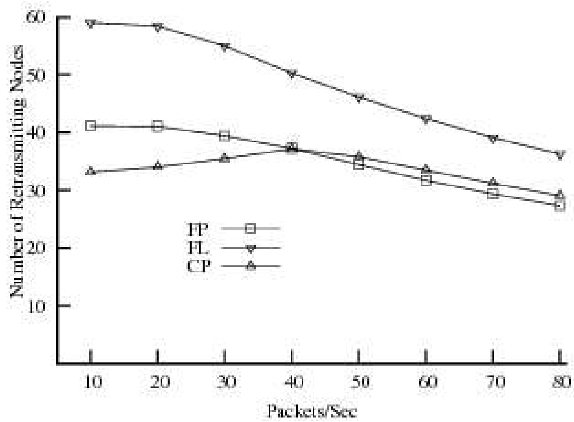


Fig. 13: Host density vs end to end delay in static and Fig.

14: Packets rate vs delivery ratio in static network
dynamic network



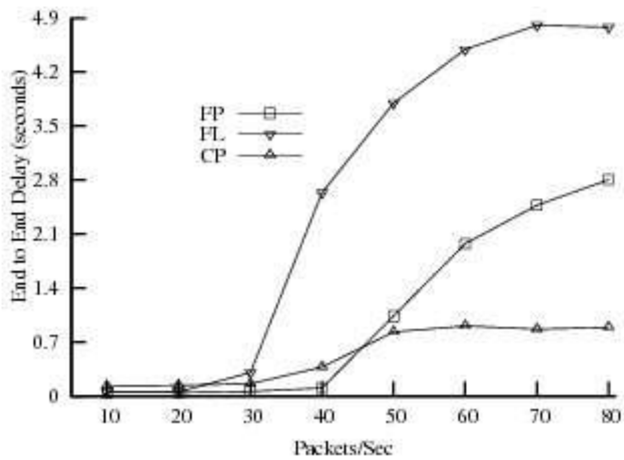


Fig. 15: Packets rate vs number of retransmitting nodes in static network

Fig. 16: Packets rate vs end to end delay in static Network

Figure 14 shows that each protocol suffers as the network becomes more congested i.e. all protocols has 100% delivery ratio when packets generation per second rate is 10 and 20 and with the increase in the packet rate, all protocols lose the delivery ratio, this is because of collisions. Figure 15 illustrates the performance of number of retransmitting nodes against packets/sec of each protocol. Since the number of nodes and the simulation area is constant, one might expect the number of retransmitting nodes to remain constant in Fig. 15. The figure shows that our CA scheme has better performance than FP scheme in less congested network and nearly equal in more congested network. Figure 16 shows the end to end delay of a packet against varying packets/sec generation rates. It can be seen from the figure that in less congested network all schemes has lower end to end delay but with the increase in the packets generation rate, all schemes suffers from longer delay. Our CA scheme out perform the flooding and fixed probabilistic in all packets per seconds generation rates.

V. Conclusion

In this study, we introduced a dynamic probabilistic broadcasting scheme based on the cover angle concept for MANETs. Our scheme combines probabilistic scheme with the cover angle-based approach [10]. A mobile host can dynamically adjust the value of the rebroadcast probability according to its cover angle covered by its neighborhood. Our simulation results show this approach has delivery ratio equal to flooding and generates fewer retransmissions than flooding and fixed probabilistic approaches. We plan to build more elaborated dynamic probabilistic approach considering cover angle concept in order to facilitate optimal adaptation strategy. As a prospect for future work, we plan to evaluate the performance of our scheme on AODV and DSR algorithms.

References

1. Joon, Y. and K.K. Chong, 2002. Reducing control overhead for acquiring neighbor knowledge in Mobile Ad Hoc Networks. In Proceedings of KISS 29th Conference, Suwon Korea.
2. Perkins, C.E. and E.M. Royer, 1999. Ad Hoc Ondemand Distance Vector Routing. Proc. 2nd IEEE Wksp. Mobile Comp. Sys. and Apps., pp: 90-100.
3. IEEE Standard for Wirless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications. ISO/IEC 8802-11: 1999 (E), Aug. 1999.
4. Ni, S.Y., Y.C. Tseng, Y.S. Chen and J.P. Sheu, 2002. The broadcast storm problem in a mobile ad hoc network. Wireless Networks, 8 (2/3): 153-167.
5. Lou, W. and J. Wu, 2002. On reducing broadcast redundancy in ad hoc wireless networks. IEEE Transactions on Mobile Computing, 1 (2): 111-123.
6. Williams, B. and T. Camp, 2002. Comparison of broadcasting techniques for mobile ad hoc networks. Proceedings of the Third ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc), pp: 194-205.
7. Haas, Z., J. Halpern and L. Li, 2002. Gossip-based Ad Hoc Routing. Proceedings of IEEE INFOCOM.
8. Sasson, Y., D. Cavin and A. Schiper, 2003. Probabilistic Broadcast for Flooding in Wireless Mobile Ad hoc Networks. IEEE Wireless Communications and Networking Conference (WCNC).
9. Zhang, Q. and D.P. Agrawal, 2003. Dynamic probabilistic broadcasting in mobile ad hoc networks. Vehicular Technology Conference, 2003. VTC 2003-Fall. 2003 IEEE 58th, 5: 2860-2864.
10. Imran, A.K., P.E. Yue, J. Nadeem and L.Q. Hua, Angle-Aware Broadcasting Techniques for Wireless Mobile Ad hoc Networks. Submitted to Information Technology Journal, http://ansijournals .com/3/c4p.php?id=1&theme=3&jid=itj
11. The Network Simulator NS 2. http://www.isi.edu /nsnam/ns/index.html.
12. Sze-Yao, Ni, Yu -Chee Tseng, Yuh-Shyan Chen and Jang-Ping Sheu, 1999. The broadcast storm problem in a mobile ad hoc network. In MobiCom ’99: Proceedings of the 5th annual ACM/IEEE international conference on Mobile computing and networking.
13. Heinzelman, W.R., J. Kulik and H. Balakrishnan, 1999. Adaptive Protocols for Information Dissemination in Wireless Sensor networks. Proc. ACM MobiCom ’99, Seattle, WA.
14. Akyildiz, I.F., Weilian Su, Y. Sankarasubramaniam and E. Cayirci, 2002. A survey on sensor networks. IEEE Communications Magazine, 40 (8): 102-114.
15. Intanagonwiwat, C., R. Govindan and D. Estrin, 2000. Directed diffusion: A scalable and robust communication paradigm for sensor networks. In the Proceedings of the 6th Annual ACM/IEEE International Conference on Mobile Computing and Networking (MobiCom'00), Boston, MA, August.
16. Braginsky, D. and D. Estrin, 2002. Rumor Routing Algorithm for Sensor Networks. In the Proceedings of the First Workshop on Sensor Networks and Applications (WSNA), Atlanta, GA, October.
17. Perkins, C. and E. Royer, 1999. Ad hoc on demand distance vector routing. Proc. 2nd IEEE Wksp Mobile Comp. Sys. & Apps.
18. Einer Vollset and Paul Ezhilchelvan, A Survey of Reliable Broadcast Protocols for Mobile Ad-hoc Networks. Probabilistic Broadcasting Based on Coverage Area and Neighbor Confirmation in Mobile Ad Hoc Networks.
19. Chin-Kai Hsu, Chien Chen and Hsien-Kang Wang, DISCOUNT: A Hybrid Probability-Based Broadcast Scheme for Wireless Ad Hoc Networks.

