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Angle-Aware Broadcasting Techniques for Wireless Mobile Ad Hoc Networks

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Abstract: In this study, cover angle-based broadcasting techniques are proposed for Mobile Ad hoc Networks (MANETs) to minimize redundancy, contention and collision known as broadcast storm problem in the literature. The propose techniques uses only cover angle concept for rebroadcast decision without using neighbors knowledge information's or complex calculations. Through the analysis and extensive simulations, the results reveal the cover angle-based broadcasting techniques exhibits superior performance in term of both delivery ratio and number of retransmission. The propose techniques are fully distributed, simple and can be easily implemented in MANETs.

Key words: Ad hoc networks, routing, broadcasting, cover angle, simulation

INTRODUCTION

MANET is an autonomous system of mobile nodes (hosts) connected with wireless links, the union of which forms an arbitrary graph. Each node in the network acts as both router and a host. They are free to move and organize themselves arbitrarily, so the topology of MANET may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger-scale Internet (Macker and Chakeres, 2008). MANET is expected to be widely used in the near future because of the flexibility. For example, it can be quickly deployed in the areas of natural disaster rescues, wireless conferences, battlefields, explorations and monitoring objects in a possibly remote or dangerous environment. Issues of broadcasting, unicasting, multicasting and QOS routing in such networks have been widely discussed in recent years.

This study addresses the broadcasting problems in MANETs. Broadcasting is a common and basic operation in MANETs, such as paging a particular host, sending an alarm signal and finding a route to a particular host, etc. Several ad hoc network protocols assume that the broadcasting service is basically available. For instance, AODV (Perkins and Royer, 1999), DSR (Johnson *et al*., 2001), TORA (Park and Corson, 1998), depends on broadcasting for route discovery and proactive routing protocols, such as DSDV and WRP (Murthy and Garciat, 1996), periodically broadcast updated information about cost metrics. With the higher characteristics in MANETs, the amount of such operations will be increased greatly.

Many approaches (Wu and Li, 1999; Ni *et al*., 1999; Williams and Camp, 2002; Haas *et al*., 2002; Sasson *et al*., 2003) are proposed for broadcasting in MANET. But none of them have been considered as an optimal method for the broadcasting. The simplest one to achieve broadcasting is through flooding. Even though flooding is very simple and reliable approach, it produces a high overhead in the network. Therefore, it leads to excessive contention, collision and redundant rebroadcasts known as broadcast storm problem (Ni *et al*., 1999). Ni *et al*. (1999) identified the broadcast storm, showing how serious it is through analysis and simulation and proposed five schemes to reduce redundant rebroadcasts and differentiate timing of rebroadcasts. The first four schemes fall in to flat category and the fifth one called cluster-based scheme belongs to hierarchical category.

In the probabilistic scheme (Ni *et al*., 1999), each node rebroadcasts the first copy of a received message with a given probability p. If $p = 1$, this scheme behaves like flooding. In the counter-based scheme (Ni *et al*., 1999), a node rebroadcasts the message if and only if it received the same message from less then C neighbors during a random number of slots. In distance-based scheme (Ni *et al*., 1999), a node rebroadcasts the message if and only if the distance to each neighboring node that has retransmitted the message is larger than a pre defined threshold D. The distance can be obtained via Global Positioning System (GPS) or can be measured by means of signal power.

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In the location-based scheme (Ni *et al*., 1999), a node retransmits the message if and only if the EAC (expected additional coverage) value held by the node is larger than the pre defined threshold A. Ni *et al.* (1999) mentioned that cost of calculating AC, which is related to calculating many intersection areas among several circles. This problem is difficult already when there are four circles. The simplified version of location-based scheme is to rebroadcast the message if the node is not located inside the convex hull of the neighboring nodes that have retransmitted the message. The authors (Ni *et al.*, 1999) conclude that among all, the location-based scheme is the best choice because it can eliminate most redundant rebroadcasts under all kinds of host distributions without compromising delivery ratio.

This study proposes cover angle-based broadcasting techniques to solve the broadcast storm problem to achieve the network reachability like plain flooding with sufficient amount of save rebroadcasts. The basic idea of present techniques is that, a node takes the broadcasting decision only on its cover angle i.e. how much cover angle has been covered by this node. The techniques presented in this study do not need extra communication overhead. The propose approaches are compare with counter-based, Location-based and simple flooding approaches under various network conditions through simulation. Simulation results show that present approaches can improve the average performance of broadcasting in various network scenarios.

COVER ANGLE-BASED BROADCASTING

Assumptions: As do many of the aforementioned broadcasting protocols (Cui *et al.*, 2005; Li and Mohapatra, 2003; Sun *et al.*, 2001; Zhu *et al.*, 2004). We assume that all nodes can obtain location information provided by technologies such as the Global Positioning System (GPS) (Dommety and Jain, 1996). This is a reasonable assumption because of the increasing availability and pervasiveness of these devices and because the GPS service is provided without charge.

In the case that GPS is not available, it is plausible that nodes may calculate their positions with a localization scheme, a research area that has recently received a lot of attention (Savvides *et al.*, 2001). Positioning or GPS devices can, in fact, provide 3-D location information in terms of longitude, latitude and altitude. In this study, for simplicity, we use a xy-coordinate system in place of longitude and latitude. Although standalone GPS is not accurate to a precise degree, there are technologies available that can, when incorporated with GPS, improve its accuracy to within centimeters, which is more than sufficient for our protocol.

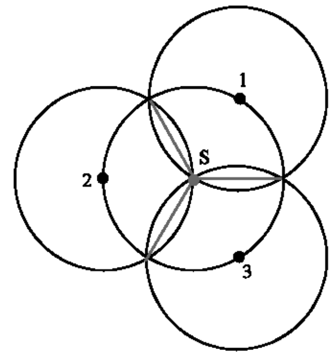

Fig. 1: Example cover angle

The geometry of the diagram shown in Fig. 1 shows that at least 3 neighbor nodes are require for broadcast to cover the broadcasting area of node S if the neighbors are located at their ideal positions otherwise more than three nodes broadcast is required to cover the broadcasting area of S. Without using the incoming packet direction it is not possible that a node always take broadcasting decision on 3 packets, it is seldom that 3 packets from ideal position cover the broadcast area of S and then S decide not to rebroadcast the same packet. Again from Fig. 1, we observe that when a node S receives a message from its neighbor at a distance equal to the transmission radius then the cover angle of S covered by the transmission of its neighbor is 120° or $0.39\pi r^2$ area of S has been covered. If sum of the disjoint cover angle of S by its number of neighbors as shown in the same figure is 360° then the broadcasting area of S has been completely covered by its neighbors and no need to broadcast the packet through this node.

From the earlier discussion and observations we propose cover angle broadcasting scheme where a node drop the packet if and only if the sum of the cover angles is equal to 360° which is mathematically show in Eq. 1:

$$\sum_{i=0}^{n} \theta_i = 360° \quad (1)$$

where, n is the number of times a node receive the same packet and θ_i is the increment cover angle. In this scheme, present objective is always to gain 100% delivery ratio like flooding regardless of any type of network topology and density i.e., sparse or dense and to decrease possible number of rebroadcast without scarifying reachability. The following describes the components of our scheme.

Distance estimation: When a node receives a flooded packet, it first extracts the position information of the sender from the header of the packet. Let (x_0, y_0) are the position coordinates of the sender and (x_1, y_1) are the coordinates of receiver then the Euclidean distance d can be estimated as:

$$d = \sqrt{(x_1 - x_0)^2 + (y_1 - y_0)^2} \quad (2)$$

Angle estimation

Packet direction angle: Before receiving any packet a node has a cover angle equal to 360° and when any packet receive by this node, cover some angle so we call it as cover angle. 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 like counter-based scheme. When a node receives a packet calculate its angle from the sender of the packet, using its own position information and the position information in the packet as in Eq. 3:

$$\tan(\gamma) = \frac{y_0 - y_1}{x_0 - x_1} \quad (3)$$

Assuming all nodes are parallel to the XY-coordinate of the network then we can easily estimate the angle position of the sender with respect to the receiver. For instance, suppose S receives packet from its neighbor N and calculate an angle $\gamma = 225°$ with respect to N. According to present assumption as shown in Fig. 2, the angle of sender N with respect to receiver S is 45° and can be calculated easily by adding 180° in the angle if $\gamma<180°$ and by subtracting 180° if $\gamma> 180°$.

Cover angle: In the Fig. 2 N is a source node initiated a broadcast route request packet and its neighbor S having cover angles 0-360° receive the broadcast packet. Let A and B are the two intersection points where N transmission intersects S transmission. Using triangle ASN we have:

$$R_S^2 = R_N^2 + d - 2R_N d\cos(ASN) \quad (4)$$

or

$$\angle ASN = \cos^{-1}\left(\frac{R_N^2 + d^2 - R_S^2}{2R_N d}\right)$$

where, R_S and R_N are the transmission radii of nodes S and N, respectively and d is the distance between them. Assuming all nodes have the same transmission radius R then the above equation becomes as given below:

$$\angle ASN = \cos^{-1}(d/2R)$$

Let α be the degree of $\angle ASN$ then the Eq. 5 can be written as:

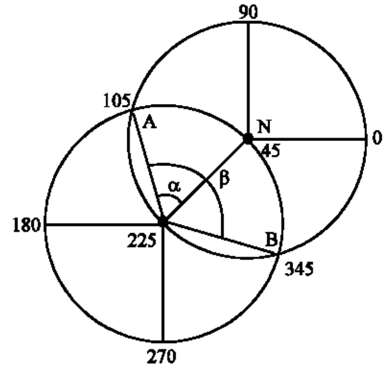

Fig. 2: Cover angle estimation

$$\alpha = \cos^{-1}(d/2R) \quad (5)$$

Let β be the degree of $\angle ASN$, having found which is half-angle of $\angle ASN$ then β can be easily computed as:

$$\beta = 2\angle ASN = 2\alpha \quad (6)$$

Now from Eq. 3 and 5 cover angle can be calculated as given below:

$$\text{Cover angle } (c_1, c_2) = ((\gamma-\alpha),(\gamma+\alpha)) \quad (7)$$

where, c_1 and c_2 are the end points of the cover angle covered by message m transmission.

Broadcast procedure: To broadcast a request packet for a destination, a source node includes the following information in the packet: Source node ID, destination node ID, packet ID and current node position. The source node ID and destination node ID fields are the node IDs of the source and destination nodes, respectively. The current node position is the position of the node that is going to broadcast this packet. (Thus, each intermediate node updates the current node position header field before rebroadcast the packet). Cover angle broadcasting works as follow when a source node has a message m to broadcast, it simply broadcasts m by passing m to the lower layer (MAC layer) When a node receives m, it checks it seen table. If m is a new message, the node sets up a time event with a period of time T and store m in Received Packet List (RCV-LIST). If m is a duplicate message, the node simply stores the packet in the received packet list. When a time event of message m is triggered, the node has to decide weather the message m should be drop or rebroadcast it. For this decision the node does the following steps:

Angle	Type

Fig. 3: Cover angle list

Source ID	Packet ID	Sender position	
		X	Y

Fig. 4: Received packet list

- Travel the received packet list and compute distance d using Eq. 2 and cover angle using Eq. 7 for each record
- Store cover angle information in the Cover Angle List (CA-LIST)
- After processing all records the node check, sum of the cover angles, if sum of cover angle is equal to 360° the node will drop the message other wise rebroadcast it. A concise sketch of the Cover Angle-Based Broadcasting is shown in Algorithm 1. Note that this locally optimal broadcasting is achieved without nodes having knowledge of their neighborhood. If all nodes have the same transmission radius, then each cover angle has at least 120° as shown in Fig. 1. The data structure of cover angle list and received packet list is as shown in Fig. 3 and 4, respectively.

COVER ANGLE-BASED BROADCASTING ALGORITHM

Algorithm 1

1: **if** m is a new message **then**
2: Set a delay time t
3: Store position (x_1, y_1) of message *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 expire
8: Set CURRENT_RCV ← First record of RCV_LIST.
9: **while** (CURRENT_RCV != NULL) **do**
10: $d_x = x_2 - x_1$, $d_y = y_2 - y_1$
11: Compute distance d using Eq. 2
12: γ = atan2 (d_x, d_y)
13: **if** ($\gamma < 0$) **then** $\gamma = (\gamma + 360)$
14: β= acos (d/2r)
15: $c_1 = (\gamma - \beta)$, $c_2 = (\gamma + \beta)$
16: **if** ($c_1 \geq o$ and $c_2 <= 360$) **then**
17: add [(c_1, 0), (c_2, 1) to the CA_LIST
18: **else if** ($c_1 < 0$) **then**
19: add [(0, 0), (c_2, 1)] and [(360+c_1, 0), (360, 1)]
20: **else if** ($c_2 > 360$) **then**
21: add [(0, 0), (c_2-360, 1)] and [(c_1, 0), (360, 1)]
22: **end if**
23: CURRENT_RCV←CURRENT_RCV–>next
24: **end while**
25: SORT CA_LIST with angle
26: Initialize INTERVEL_DEPTH = 0
27: Set CURRENT_REC←First record of CA_LIST
28: **while** (CURRENT_ REC != NULL) **do**
29: **if** (CURRENT_REC–>type = = 0) **then**
30: increase INTERVAL_DEPTH by 1.
31: **if** (INTERVAL_DEPTH > 1) **then**
32: remove CURRENT_REC
33: **else**
34: CURRENT_REC←CURRENT_REC–>next
35: **end if**
36: **else if** (CURRENT_REC–>type = = 1) **then**
37: decrease INTERVAL_DEPTH by 1.
38: **if** (INTERVAL_DEPTH > 0) **then**
39: remove CURRENT_REC
40: **else**
41: CURRENT_REC←CURRENT_REC–>next
42: **end if**
43: **end if**
44: **end while**
45: LABEL-3:
46: Set CURRENT_REC← First record of CA_LIST.
47: **if** ((CURRENT_REC–>angle = = 0) and (CURRENT_REC–>angle–>next = = 360) **then**
48: cancel Retransmission
49: **else**
50: Rebroadcast
51: **end if**

Improved cover angle-based broadcasting algorithm: Cover angle based broadcasting scheme rebroadcast the message even if a very small cover angle has not been covered as shown in Fig. 5 that node 2 received the same message from nodes 1, 3, 4, using cover angle broadcasting scheme this node must be rebroadcast the message because the sum of cover angle is not equal to 360. We argue that this small uncovered angle will not

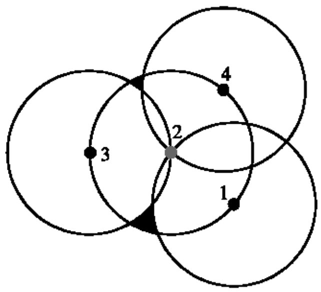

Fig. 5: Small uncovered area

affect the reachability of the message because most of the inner area has been covered except a very small area near to the boundary, but increase the save rebroadcasts. To support present argument location based scheme is consider efficient among others uses polygon test method, when a node is not exactly at the center of polygon 0~22% area has not been covered by this node even then the node drops this message. Taking in to account this we proposed an Improved Cover Angle-based Broadcasting scheme which is briefly explain in Algorithm 2.

IMPROVED COVER ANGLE-BASED BROADCASTING ALGORITHM

Algorithm 2

Add Algorithm 2 to Algorithm 1 before LABEL_3.
get records into c_i (i = 1 to 6) from CA_LIST
Label_1:
if (count = 2) **then**
get c_1, c_2
if (c_1 = 0 and c_2 = 360) **then**
go to LABEL_3:
end if
if (c_1 - (c_2-360) < SMALL_INTERVAL) **then**
Set LIST to [(0, 0), (360, 1)]
end if
else if (count = 4) **then**
get c_1, c_2, c_3, c_4
if (c_B-c_2) < SMALL_INTERVAL **then**
set the list to [(c_1, 0), (c_4, 1)]
go to Label_1
end if
if (c_1 = = 0 and c_2 = = 360) **then**
go to LABEL_3:
end if
if (c_1-(c_4-360) <SMALL_NTERVAL) **then**
Set LIST to [(0, 0), (c_2, 1)],[(c_3, 0), (360, 1)]
go to Label_1:
end if
else if (count = = 6) **then**
get c_1, c_2, c_3, c_4, c_5, c_6
if ((c_3-c_2) < SMALL_INTERVAL) **then**
Set LIST to [(0, 0), (c_4, 1)], [(c_5, 0), (360, 1)]
go to Label_1:
end if
if ((c_5- c_4) < SMALL_INTERVAL) **then**
Set LIST to [(0, 0), (c_2, 1)], [(c_3, 0), (360, 1)]
end if
end if

Cover angle threshold-based broadcasting: Ni *et al.* (1999) and Williams and Camp (2002) claim to gain 100% reachability by using the counter threshold value = 3. We think that it was possible in high density network where some surrounding nodes not its own neighbors will help to cover the broadcasting area of S. Taking into account this we proposed a cover angle threshold based broadcasting scheme to gain more save rebroadcast, which is describe as follow.

When a node receives a message for the first time, start a delay time (T) before rebroadcast the packet. During this period the node will sum up the cover angles and compare with a predefined threshold angle say λ. If after delay time if sum of the cover angles is less than or equal to λ the node will rebroadcast the packet, otherwise not. A concise sketch of the cover angle threshold based broadcasting algorithm is shown in Algorithm 3.

COVER ANGLE THRESHOLD-BASED BROADCASTING

Algorithm 3

Add Algorithm-1 before LABEL_3.
set SCA = 0
set CURRENT_REC?First record of CA_ LIST.
while (CURRENT_REC != NULL) **do**
set c_1 = CURRENT_REC–>angle
CURRENT_REC = CURRENT_REC–>next
set c_2 = CURRENT_REC–>angle
CURRENT_REC = CURRENT_REC–>next
SCA = SCA + (c_2-c_1)
end while
LABEL_4:
if (SCA > threshold) **then**
cancel retransmission
else
rebroadcast
end if

Example: We assumed that the angle threshold value is 300°. Suppose node N_0 receives a packet from N_1 and compute the angle cover by the broadcast. Suppose the angle cover by this broadcast is 120°. At t_1<T, N_0 receives the same packet from N_2, compute the cover angle, suppose which is 160°, the incremental angle from the previous broadcast is 90° and the sum up the incremental angle to the previous becomes 210°, which is still less than threshold value. At t_2<T, node N_0 receive another copy of packet from N_3 and sum up the cover angle becomes 310°, which is greater than the threshold value. The condition has been met and the packet will be dropped.

Selection of maximum delay time: When a node receive the message for the first time, a maximum delay time also called jitter time is given to a node for that message mainly for two purposes.

- To avoid collisions and simultaneous packet broadcast
- To receive enough number of the same packets for decision weather to drop the packet or retransmit it again

If a very short maximum delay time is selected which obviously decreases the end to end delay but affect the performance of the broadcasting protocols in term of save rebroadcasts. To observe this we simulate Location-based scheme (Ni *et al.*, 1999) with 60 nodes in the network area of size 350×350 having 100 m transmission radius against different maximum delay times. As shown in Fig. 6 that when the value of maximum delay time is 10 msec the Location-based scheme behaves like plain flooding because 10 msec are not enough for location-based scheme to receive enough number of the same packets and make a polygon test for rebroadcast decision. When the value of maximum delay time increases the Location-based scheme saved more rebroadcast without scarifying reachability. When the value of maximum time is earlier 50 msec there is no effect on saved rebroadcast with 100% reachability but the end to end delay increases. We conclude that maximum delay time effect the performance of the broadcasting protocols in term of saved rebroadcasts for the protocols which used some broadcasting algorithms for broadcasting decision unlike plain flooding or counter based scheme where a simple condition is checked for the broadcasting decision and may be such protocols can perform well with the selection of short maximum delay time. Taking in to account this we select the 60 msec for Max-delay time in present all simulations.

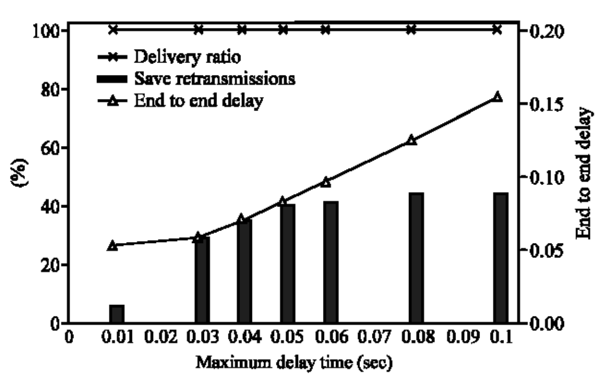

Fig. 6: Effect of delay time

PERFORMANCE EVALUATION

Simulation description: In order to evaluate present approaches, we implemented and perform simulations using the network simulator called NS-2 which supported CMU wireless extension. The simulation parameters are shown in Table 1. Each node in the network has a constant transmission range of 100 m. We use a two-ray ground reflection model as the radio propagation model. The MAC layer scheme follows the IEEE 802.11 MAC specification. We use the broadcast mode with no RTS/CTS/ACK mechanisms for message transmission. The random waypoint model is used as the mobility model. In this model each node at the beginning of the simulation remains stationary for pause time seconds, then chooses a random destination and starts moving towards it with speed selected from a uniform distribution (0, Max-speed). After the node reaches that destination, it again stands still for a pause time interval and picks up a new destination and speed. This cycle repeats until the simulation terminates. During simulation randomly selected nodes start to send broadcast packets of size 64 bytes at the rate of 10 packets/sec. This procedure last for 100 sec. To make sure all the broadcast packets propagate through the network, the simulation will last for another 10 sec after the last broadcast process has been sent. We first test the performance variation with network size increases while keeping host density nearly constant. Secondly, we test the performance variation with host density varies while keeping the tertian size unchanged. We run the simulation 10 times to achieve a 90% confidence interval for the results.

Table 1: Fixed simulation parameters

Parameters	Values
Simulator	NS-2 (version 2.29)
Transmission range	100 m
MAC layer	IEEE 802.11
Data packet size	64 bytes
Bandwidth	2 Mb sec^{-1}
Simulation time	100 sec
No. of trails	10
Confidence interval	90%
Max-delay time	0.06 sec

We simulate and compare the following broadcasting protocols: Plain Flooding (PL), Counter Based (CB), Location Based (LB) and present Cover-Angle Based broadcasting techniques (Cover-Angle Based Broadcasting (CA), Improved Cover-Angle Based Broadcasting (ICA) and Cover-Angle based threshold broadcasting (CA-th)). All the protocols use 60 msec for Max-delay. For counter based, we set the value of the counter threshold to C = 3 in accordance with (Ni *et al*., 1999).

Performance Metrics: The performance of broadcast protocols can be measured by a variety of metrics (Ni *et al*., 1999; Williams and Camp, 2002). In this study, we use rebroadcast savings, delivery ratio and average end to end delay, which are complementary measures and are precisely defined below. The formal definitions of these three metrics are given as follows (Ni *et al*., 1999).

No. of transmitting nodes: It can be defined by $(n_r - n_t/n_r)$ where, n_r is the number of hosts receiving the broadcast message and n_t is the number of hosts that actually transmitting the message.

Delivery ratio: It is defined as $n_r/(n_0-1)$ where, n_0 is the total number of hosts in the network. For meaningful information, the total number of nodes should include those nodes that are part of a connected component in the network. For disconnected networks this measure should be applied to each of the components separately.

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

$$d = \sum_{i \in R} d_i |R|$$

where, R is the set of nodes that received the message. |R| is the number of nodes in the set R and d_i is the delay of the message transmitted from source to node I.

SIMULATION RESULTS

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 0 m sec^{-1} while the maximum speed is set as 20 m sec^{-1}. We set the pause time 0 second to test mobility adaptability.

Figure 7 shows the delivery ratio (the percent of network nodes that receive any given broadcast packet) for each protocol as the network size increased in a static network i.e., speed = 0. Fig. 7a shows that flooding scheme has the highest delivery ratio in dense network (from 1×1 to 6×6) but when the network size becomes sparser, the delivery ratio of flooding scheme decreases i.e., for sparse network 9×9 the delivery ratio approaches to 30%, because there are not enough nodes to retransmit the broadcast packet. Present schemes CA, ICA and the location-based scheme (LB) have the same delivery ratio like flooding in all cases. Only counter-based scheme (CB) and our CA-th scheme suffer from delivery ratio in sparse network, but CA-th has a bit better delivery ratio performance than counter-based scheme. Figure 7b shows that the delivery ratios of all the broadcasting schemes are higher when nodes are moving with speed = 20 m sec^{-1}. All the broadcasting schemes has more than 60% delivery ratio in sparse networks.

Figure 8 shows the number of retransmitting nodes required by each protocol as the network size increases.

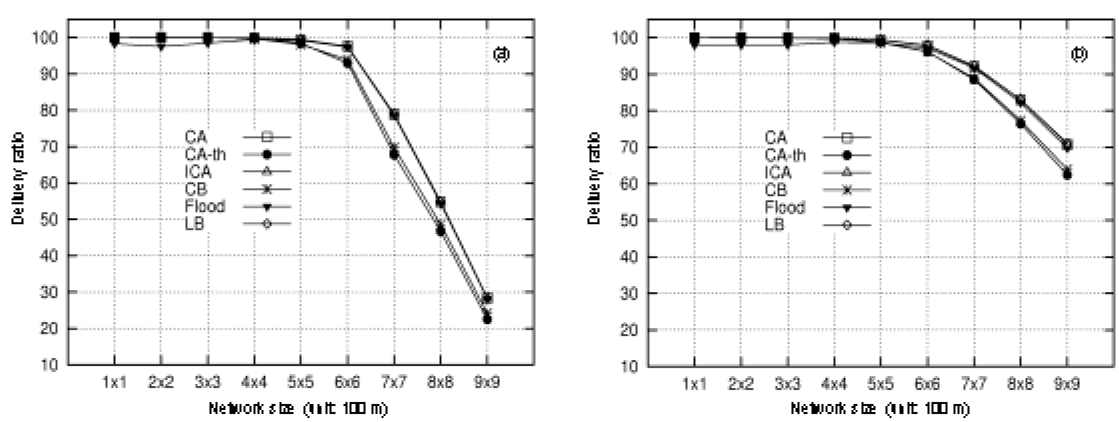

Fig. 7: Network size versus delivery ratio with no mobility and with mobility, (a) Speed = 0 and (b) 20 m sec^{-1}

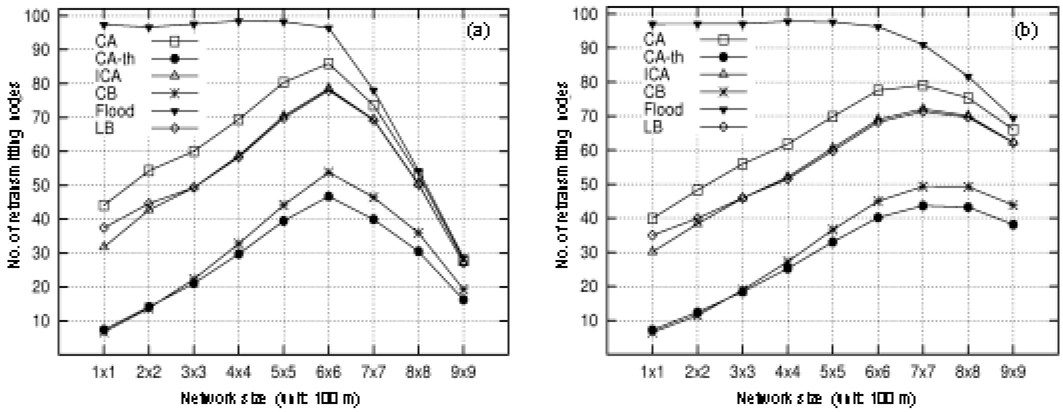

Fig. 8: Network size versus No. of retransmitting nodes with no mobility and with mobility, (a) Speed = 0 and (b) 20 m sec^{-1}

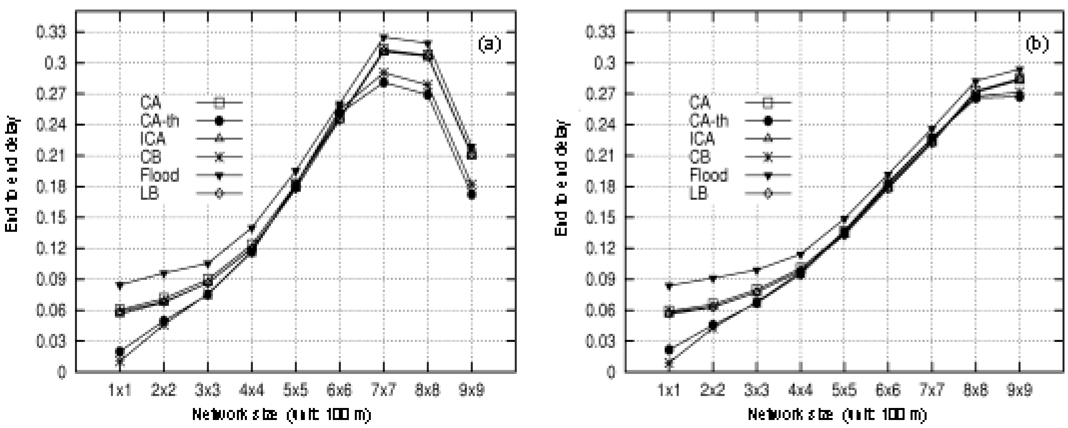

Fig. 9: Network size versusend to end delay with no mobility and with mobility, (a) Speed = 0 and (b) 20 m sec^{-1}

The Fig. 8a shows that as expected in flooding scheme all the nodes retransmit the packet. It can be shown from the Fig. 8 that when the network size is 6×6, the nodes are within the reach of each other, flooding scheme retransmit all the received packets, CA scheme saved about 56% retransmission in the dense network and 25% retransmission in sparse network. Present ICA scheme has better performance than location-based scheme (LB) in dense network and equal or a bit good performance in sparse network.

Figure 9 shows that all the schemes saved more retransmission when the network size increases, but in fact it is because when the network size increases some of the nodes are isolated from others in the network and could not received the broadcast packet. The figure shows that in all network scenarios CA-th out performs among all broadcasting schemes.

The Fig. 8b shows that mobility improves the performance i.e., decreases the number of retransmitting nodes and keeps the network connected as compared to static network.

Figure 9a shows that end to end delay of all schemes increases with the increase of network size and all schemes has end to end delay equal or less than flooding. Figure 9b shows that dynamic network reduce the packet end to end delay time than static network.

Effect of host density and mobility on performance: Simulation parameters are the same as those used in the previous simulation except for terrain size and number of hosts. In this simulation the density varies from 20 to 125 nodes placed randomly on 350×350 area.

Figure 10a shows that delivery ratio increases when network density increases, regardless of what kind of the

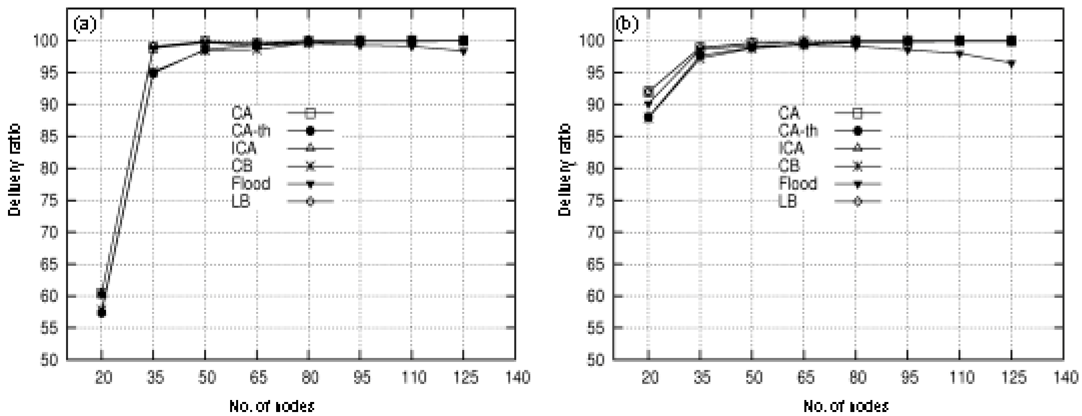

Fig. 10:No. of nodes versus delivery ratio with no mobility and with mobility, (a) Speed = 0 and (b) 20 m sec^{-1}

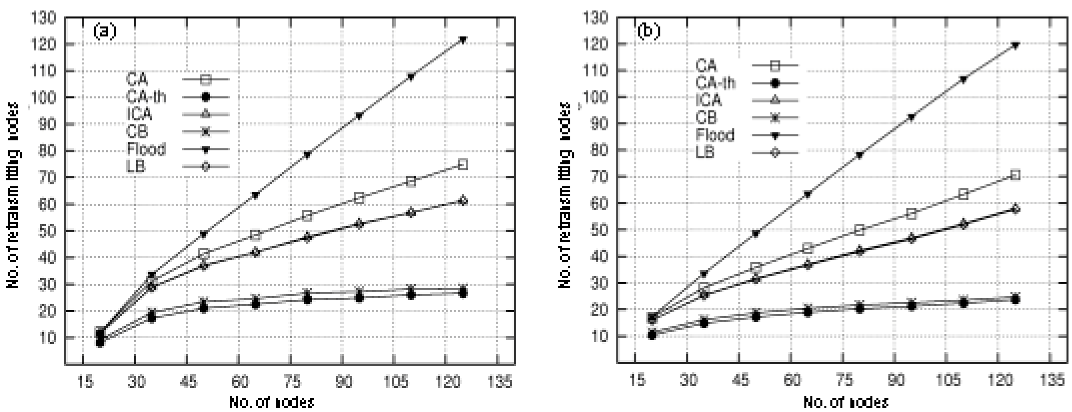

Fig. 11:No. of nodes versus No. of retransmitting nodes with no mobility and with mobility, (a) Speed = 0 and (b) 20 m sec^{-1}

algorithm is used. It shows that all schemes have best delivery ratio performance in all node densities except node density 20. It can be observed from the figure that in a very congested network flooding scheme a bit suffer from delivery ratio because of collisions.

Figure 10b compare the delivery ratio performance of all broadcasting schemes and shows that mobility improve the delivery ratio performance. It shows that when there is high mobility all schemes have more than 88% delivery ratio in all scenarios.

Figure 11a shows the number of retransmitting nodes of all the schemes. Figure 11 shows that in our CA scheme less number of nodes retransmit the same packet when compare to flooding where every node retransmit the packet, so our CA is a good choice to save reasonable amount of retranamission with guarantying 100% delivery ratio. It shows that ICA has the same performance like LB, while CA-th has better performance than Counter-Based scheme (CB) in all node densities. Figure 11b shows that mobility decreases the number of retransmitting nodes of all schemes in all densities.

Figure 12a and b shows the simulation results of end to end delay with no mobility and host mobility of 20 m sec^{-1}. Figure 12a shows that all schemes have longer delay in sparse networks. Flooding scheme has longer end to end delay than all other schemes. Figure 12b shows that mobility improves the end to end delay of all broadcasting schemes. Here one can argue that why flooding scheme suffer from longer delay, because we use 0.06 sec for maximum delay time for all schemes to save more retransmission with keeping 100% delivery ratio as discussed in the section selection of maximum delay time otherwise flooding scheme out performs all other schemes in end to end delay time with the selection of maximum delay time 0.01 or 0.02 sec.

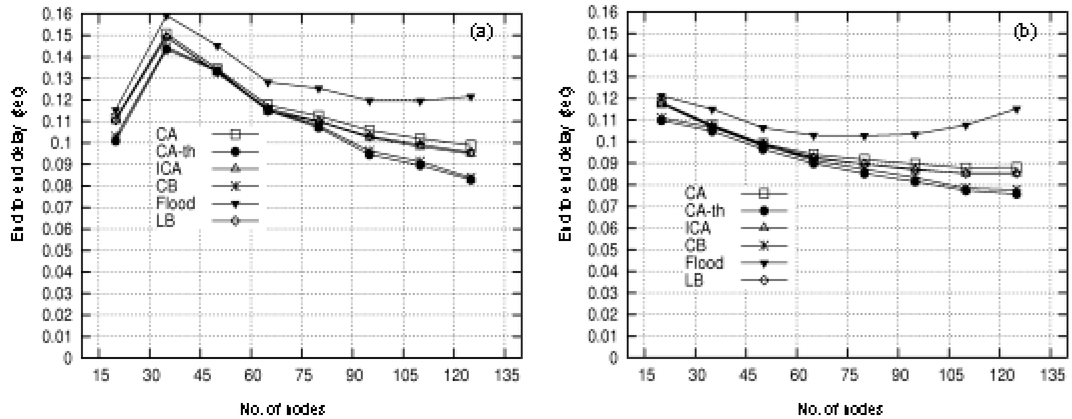

Fig. 12: No. of nodes versus end to end delay with no mobility and with mobility, (a) Speed = 0 and (b) 20 m sec^{-1}

CONCLUSION

In Mobile Ad hoc Networks (MANETs) nodes change their position frequently and to accommodate this dynamically changing topology, MANETs routing protocols uses broadcasting to get, up to date knowledge of the network or to find routes immediately. An important problem with broadcasting is how to reduce the number of retransmissions while keeping good packet delivery ratio and retransmission delay. In this study, we introduced cover angle-based broadcasting techniques to solve the broadcast storm problem caused by simple flooding for wireless mobile ad hoc networks. In present broadcasting techniques hosts uses Global Position System (GPS) for calculating the positions of the sender and rebroadcast decision is taken only on the cover angle concept without maintaining the neighbors knowledge information's. The propose techniques are compare with flooding and two other well known i.e., counter-based and location-based schemes. Simulation experiments shows that present CA broadcasting is a good choice in place of plain flooding with reachability equal to flooding and save about 25 to 40% retransmissions. Present ICA broadcasting technique has equal or better performance than location-based scheme and also efficient in time complexity than location-based scheme which needs O(nlogn) time to compute a convex hull but ICA need O(n) time, where n is the number of cover angle ranges in the cover angle sum. From the results we see that present CA-th scheme has out perform all the schemes in all scenarios of all experiments, So CA-th with angle threshold value = 200° is a good choice in place of counter based scheme which uses C =3 for rebroadcast decision. As a prospect for future study, we plan to evaluate the performance of our cover angle-based broadcasting techniques on AODV and DSR algorithms.

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