Modified Ultra Smart Counter Based Broadcast Using Neighborhood Information in MANETS

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ABSTRACT

Broadcasting protocol heavily affects performance of Mobile Ad Hoc Networks (MANET). Counter-based scheme can reduce the number of rebroadcasts, and as a result reduce Broadcast Storm Problem. Previously fixed counter-based broadcasting was used irrespective of node/network status; this research demonstrates that dynamically adjusting the counter-based to take into account neighborhood information over 1- hop improves network performance in terms of both saved rebroadcasts and degree of Reachability. This paper presents Modified Ultra Smart Counter Based Broadcast Algorithm [MUSCBA] where the threshold value at the nodes is dynamically adjusted using one-hop neighborhood information.

We have conducted simulation experiments to characterize node neighborhood in MANETs using 'Hello' packet exchange. This research argues that neighboring information could be used to better estimate the counter-based threshold value at a given node. Additionally results of extensive simulation experiments performed in order to determine the minimum and maximum number of neighbors for a given node is shown. This is done based on locally available information using AODV protocol and without requiring any assistance of distance measurements or exact location determination devices.

Keywords- MANET, Counter-Based, Flooding, Reachability, Neighborhood Information, Broadcast Storm Problem,

I. INTRODUCTION

The self-configuring nature of MANETs makes them suitable for a wide variety of applications [2]. One of the applications of this type of networks is communication within groups of people with laptops and other hand-held devices. In addition to that communication in battlefield and home networking [1, 2, 10].

Broadcasting is a fundamental operation in ad hoc networks whereby a source node sends the same packet to all the nodes in the network. In the one to- all model, transmission by each node can reach all nodes that are within its transmission radius, while in the one-to-one model, each transmission is directed toward only one neighbor (using narrow beam directional antennas or separate frequencies for each node) [3]. Broadcasting has been studied in the literature mainly for the one to-all models, and most of this study is devoted to that model.

A counter bases approach to flooding has been suggested in [4, 5, 6] as a means of reducing redundant rebroadcasts and alleviating the broadcast storm problem. The counter-Based is based on a counter c that is used to keep track of the number of times the broadcast packet is received, when receiving a broadcast message for the first time the counter c that records the number of times a host has received the same broadcast packet and is maintained by each host for each broadcast packet. When c reaches a predefined threshold c, we inhibit the host from rebroadcasting this packet because the benefit (the additional coverage) could be low [3].

Studies [3, 4, 5] have shown that counter based broadcasts incur significantly lower overhead compared to blind flooding while maintaining a high degree of propagation for the broadcast messages. This paper proposes the Modified Ultra Smart counter-based broadcast algorithm is based on a counter c that is used to keep track of the number of times the broadcast packet is received. A counter threshold is decided based on neighboring information. That is a sparse network has a different threshold than a medium sparse, medium, medium dense or dense network, we call them c1, c2, c3, c4, c5 respectively. Whenever c is greater than or equal to the threshold, the rebroadcast is inhibited.

This paper proposes Modified Ultra Smart counter-based broadcast algorithm that dynamically adjust the rebroadcasting threshold value as per the node's neighborhood distribution over one hops neighborhood. This is done based on locally available information and without requiring any assistance of distance measurements or exact location determination devices. The proposed algorithm, referred to as the smart counter-based broadcast, only information on one-hop neighbors is required. Short 'Hello' packets, containing the *ID* of the senders only, are used to collect such information. Furthermore, the algorithm does not require a positioning system, because a node

compares the neighbor lists to deduce counter based threshold information. In the algorithm, the counter based threshold in nodes located in sparse regions is set lower than those located in dense regions. The rest of this paper is organized as follows: In Section 2, we introduce the related work of broadcasting in MANETs. In Section 3, we describe our Modified Ultra smart counter based approach. In Section 4, we evaluate our approach and present the simulation results. Section 5, concludes the paper and offers suggestions for future work.

II. RELATED WORK

One of the earliest broadcast mechanisms is flooding, where every node in the network retransmits a message to its neighbors upon receiving it for the first time. Although flooding is very simple and easy to implement, it can be very costly and may lead to a serious problem, often known as the broadcast storm problem [4, 5, 6, 8] that is characterized by high redundant packet retransmissions, network contention and collision. Ni et. al. [4, 5, 6] have studied the flooding protocol analytically and experimentally. Their obtained results have indicated that rebroadcasts could provide at most 61% additional coverage and only 41% additional coverage on average over that already covered by previous transmissions. Therefore, rebroadcasts are very costly and should be used with caution [4, 5].

Williams and Camp [3] have classified the broadcast protocols into flooding, probability-based, counter-based, distance-based, location-based and neighbor knowledge schemes. Similarly, neighbor knowledge schemes can be divided into selecting forwarding neighbors and clustering-based. In counter-based scheme inhibits the rebroadcast if the packet has already been received for more than a given number of times. In the probabilistic scheme [7, 9], when receiving a broadcast packet for the first time, a node rebroadcasts the packet with a probability p; when p=1, this scheme reduces to blind flooding. In the distance-based scheme a node rebroadcasts the packet only if the distance between the sender and the receiver is larger than a given threshold. In the location-based scheme, a node rebroadcasts a packet only when the additional coverage due to the new emission is larger than a certain bound. In the selecting forwarding neighbors a broadcasting node selects some of its 1-hop neighbors as rebroadcasting nodes. Finally, the cluster structure is a simple backbone infrastructure whereby the network is partitioned into a group of clusters. Each cluster has one cluster head that dominates all other members in the cluster. A node is called a gateway if it lies within the transmission range of two or more cluster heads. Gateway nodes are generally used for routing between clusters. The rebroadcast is performed by cluster heads and gateways. However, the overhead of cluster formation and maintenance cannot be ignored [3, 11].

The counter-based scheme is a simple way of controlling message floods. Counter-based broadcast was first proposed in [4, 5, 6] as a fixed Counter-based broadcast. It has a counter c that records the number of times a host has received the same broadcast packet and is maintained by each host for each broadcast packet. When c reaches a predefined threshold c, we inhibit the host from rebroadcasting this packet because the benefit (the additional coverage) could below. After that an adaptive Counter-based scheme was proposed in [4, 5, 6] as it extended the fixed threshold C into a function $C(n)$, where n is the number of neighbors of the host under consideration. Thus, each host will use a threshold $C(n)$ depending on its current value of n to determine whether to rebroadcast or not. To this point the function $C(n)$ is undefined yet [8].

A straightforward method for gathering neighborhood information at a given node involves the periodic exchange of 'Hello' packets between neighbors to construct a 1-hop neighbor list at the nodes. A high (low) a number of neighbors implies that the node in a dense (sparse) area. The higher is the number of neighbors, the denser the network area is. The lower the number of neighbors is sparser the network area is. We will show in the subsequent paper that neighborhood information such as the average number of neighbors of the node can be used to efficiently estimate the counter based threshold value at the network nodes. In this paper, we report results from Ns-2 as the simulation platform [12]. Ns-2 is a popular discrete event simulator which has originally been designed for wired networks and has been subsequently extended to support simulations in MANET settings in order to characterise neighborhood information, such as the average number of neighbors of a given node by means of 'Hello' packet exchanges. We also investigate the effects of node mobility and network density on such gathered information. Our study is motivated by the fact the periodic 'Hello' packet for ad-hoc networks stems from the hello protocol of AODV [10]. Such a protocol and its utility have been explicitly studied by Chakeres et al. [10]. The authors have studied the hello protocol in 802.11 ad-hoc networks but have focused on a limited type of information (i.e., connectivity or forward a packet). We will show in the subsequent sections how we use the findings of this paper to introduce new and efficient class of counter based broadcast flooding algorithm for MANETs.

III. MODIFIED ULTRA SMART COUNTER BASED BROADCAST ALGORITHM [MUSCBA]

The counter based scheme [4, 5, 6, 8] is one of the alternative approaches to simple flooding that aims to reduce redundancy through rebroadcast timing control in an attempt to alleviate the broadcast storm problem. In this scheme, when receiving a broadcast message for the first time it has a counter c that records the number of times a host has received the same broadcast packet and is maintained by each host for each broadcast packet. When c reaches a predefined threshold c, we inhibit the host from rebroadcasting this packet.

In dense networks, multiple nodes share similar transmission range. Therefore, these thresholds control the frequency 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 threshold parameter is low. So if the threshold c is set to a far smaller value, Reachability will be poor. On the other hand, if c is set far large, many redundant rebroadcasts will be generated.The need for dynamic adjustment, thus, rises.

The counter based threshold value should be set low at the hosts in sparser areas and high at the hosts in denser areas. Our simple method for density estimation requires mobile hosts to periodically exchange HELLO messages between neighbours to construct a 1-hop neighbour list at each host. A high a number of neighbours implies that the hosts in denser areas, a low number of neighbors imply that the host is in sparser areas. We increase the counter based threshold value if the value of the number of neighbours is too high (or similarly if the current node is located in a dense neighbourhood), which indirectly causes the threshold value at neighbouring hosts to be decremented. Similarly, we decrease the counter based threshold value if the value of number of neighbours is too low.

The Modified Ultra Smart counter-Based broadcast algorithm is based on a counter c that is used to keep track of the number of times the broadcast packet is received. A counter threshold is decided based on neighboring information. That is a sparse network has a different threshold than a medium or dense network, we call them c1 ,c 2, c3 ,c4, and c5 respectively. Whenever c is greater than or equal to the threshold, the rebroadcast is inhibited. The algorithm works as follows

On hearing a broadcast packet m at node X, the node rebroadcasts the packet according to a low counter based threshold value, say c1 , if the packet is received for the first time, and the number of neighbours of node X is less than the minimum numbers of neighbours, $n1$. Alternatively, if the number of neighbours of the node X is greater or equal the minimum number of neighbours, $n1$, and the number of neighbours less than or equal the numbers of neighbours, $n2$, X has a sparse medium degree and the counter based threshold value is set at $c2$ such that $c1 < c2$. If the number of neighbours of the node X is greater or equal the neighbours, $n2$, and the number of neighbours less than or equal the numbers of neighbours, $n3$, X has a medium degree and the counter based threshold value is set at $c3$.

If the number of neighbours of the node X is greater or equal the neighbours, $n3$, and the number of neighbours less than or equal the numbers of neighbours, $n4$, X has a medium dense degree and the counter based threshold value is set at $c4$. Otherwise, if the number of neighbours of the node X is greater than maximum number of neighbours, $n4$, then the counter based threshold value is set high, $c5$, where $c1 < c2c < c3 < c4 < c5$. A brief outline of the new algorithm is presented below

1. **On hearing a broadcast packet m at node X**
2. **Get the Broadcast ID from the packet;**
   - **n1 = 20 % number of neighbours**
   - **n2 = 40 % number of neighbours**
   - **n3 = 60 % number of neighbours**
   - **n4 = 80 % number of neighbours;**
3. **Get degree n of node X (number of neighbors of node X);**

4. **If n ≤ n1 then**

   4.1 Sparse network
   4.2 Node X has a low degree: the low threshold value (threshold = c1);

5. **Else If n > n1 and n ≤ n2 then**

   5.1 Medium Sparse network
   5.2 Node X has a Sparse medium degree: the Sparse medium threshold value (threshold = c2);

6. **Else If n > n2 and n ≤ n3 then**

   6.1 Medium network
   6.2 Node X has a medium degree: the medium threshold value (threshold = c3);

7. **Else If n > n3 and n ≤ n4 then**

   7.1 Medium Dense network
   7.2 Node X has a Medium high degree: the high threshold value (threshold = c4);

8. **Else If n > n4 then**

   8.1 Dense network

8.2 Node X has a high degree: the high threshold value (threshold = c5);

9. **End if**
10. **counter = 1**
11. **The Packet is Broadcasted**
12. **Increment c**
13. **If (c < threshold)**
    13.1 Goto step 11

14. **Else**
    14.1 exit algorithm

15. **End if**
    End

Fig. 1: Modified Ultra Smart counter-Based broadcast algorithm [MUSCBA]

We will show in the subsequent sections that neighbourhood information such as the minimum and maximum number of neighbours of the node can be used to efficiently estimate the counter based threshold values at the network nodes. In this paper, we report results from ns-2 [4] simulations in order to characterise neighbourhood information, such as the minimum and maximum number of neighbours of a given node by means of 'Hello' packet exchanges. We also investigate the effects of node mobility and network density on such gathered information.

IV. PERFORMANCE EVALUATION

We have used ns-2 as the simulation platform [4]. Ns-2 is a popular discrete-event simulator which has originally been designed for wired networks and has been subsequently extended to support simulations in MANET settings. The density of the nodes is sufficient to maintain good network connectivity levels, with each node engaging in communication transmitting within 250 meter radius and having bandwidth of 2Mbps. The parameters used in the following simulation experiments are listed in Table 1. The MAC layer scheme follows the IEEE 802.11 MAC specification. We have used the broadcast mode with no RTS/CTS/ACK mechanisms for all packet transmissions, including Hello, DATA and ACK packets. The interface queue length has been selected because it has been used in many previous similar studies [5, 6]. Moreover, this has been found to reduce the number of drop packets at the link layer protocol due to increased packet collisions. The movement pattern of each node follows the random way-point model. Each node moves to a randomly selected destination with a constant speed between 0 and the maximum speed. When it reaches the destination, it stays there for a random period and starts moving to a new destination. We have varied the network density (i.e., the number of nodes on a given terrain size) and have measured the minimum and maximum number of neighbours over the whole nodes in the network. For each configuration, we have gathered statistics for 30 arbitrary topologies where nodes are initially placed randomly over the terrain. The results represent the average over the 30 different topologies in order to achieve a 95% confidence interval in the collected statistics. For a given number of nodes, three terrain sizes have been considered: 600m × 600m, 800m × 800m and 1000m ×1000m.

Table1. Summary of the parameters used in the simulation experiments.

Parameter	Value
Transmitter range	250 meters
Bandwidth	2Mbps
IFQ Type Queue /DropTail /PriQueue	50 packets
Simulation time	900 seconds
Pause time	0 seconds (continuous mobility)
'Hello' packet size	12 bytes
Topology size	600m × 600m, 800m × 800m and 1000m ×1000m
Number of nodes	25, 50, 75, 100, 125
Maximum speed	2 and 20 m/s

Figures 2 and 3 depict the minimum and maximum number of neighbours after averaging over the whole network nodes when the nodes move at the max. speed of 2m/s. Various network densities resulting from a combination of different network sizes (from 25 to 125 nodes) and terrain sizes (600m×600m, 800m×800m, and 1000m×1000m) have been examined. A summary of the minimum and maximum number of neighbours is listed in Table 2. Also a summary of confidence intervals, margin errors for the minimum and maximum number of neighbours of a given node (averaged over the whole network) is shown in Table 3. The results show that as expected the denser the network is, the higher the maximum number of neighbours is at a given node. On the other hand, the sparser the network is, the lower is the minimum number of neighbours at a given node. As the network size increases so does the minimum and maximum number of neighbours. For example, in a terrain size of 1000m × 1000m when the network size is 50 nodes, a typical node has the minimum number of neighbours equals to 6, the maximum number of neighbour to 24. When the network size is doubled to 100 nodes, a typical node has the minimum number of neighbours equals to 6, the maximum number of neighbour to 47. Figures 4 and 5 provides further results on the minimum and maximum number of neighbours (averaged over the whole

network) after repeating the above simulation experiments where the node speed is set at 20 m/s.
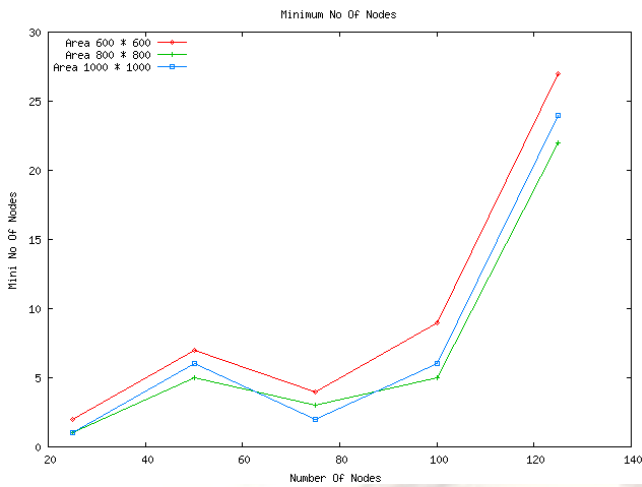

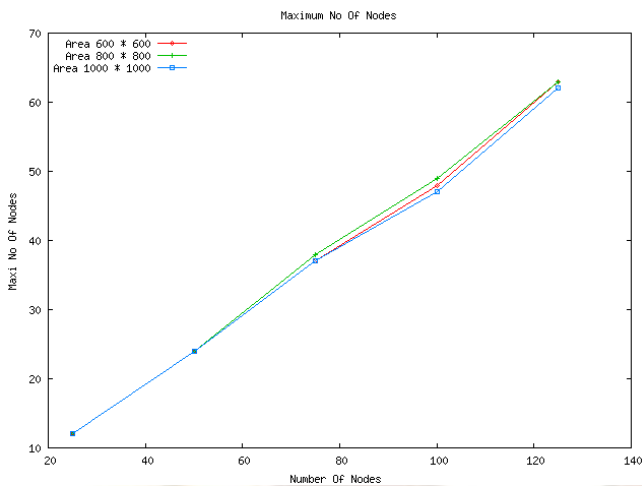**Fig. 2. Minimum numbers of neighbours vs. network size with a node speed of 2 m/s.**

Fig. 3. Maximum number of neighbours vs. network size with a node speed of 2 m/s.

Table 2. Summary of the minimum and maximum number of neighbours of given node

Number of Nodes	Average Minimum of neighbours (average +- std)	Average Maximum of neighbours (average +- std)
25	1+- 0.50	10+-0.3
50	5+-0.50	21+-0.3
75	3+-0.5	34+-0.5
100	6+-0.5	45+-0.2
125	22+-0.3	60+-0.3

Table 3. Summary of confidence intervals and margin of errors of minimum number of neighbors of given node

Number of Nodes	95% confidence interval for Minimum no of neighbors	Relative errors
25	2.20-3.10	0.5
50	4.20-5.20	0.3
75	2.40-5.30	0.4
100	6.20-7.40	0.5
125	8.10-9.20	0.3

Table 4 Summary of confidence intervals and margin of errors of maxmum number of neighbors of given node

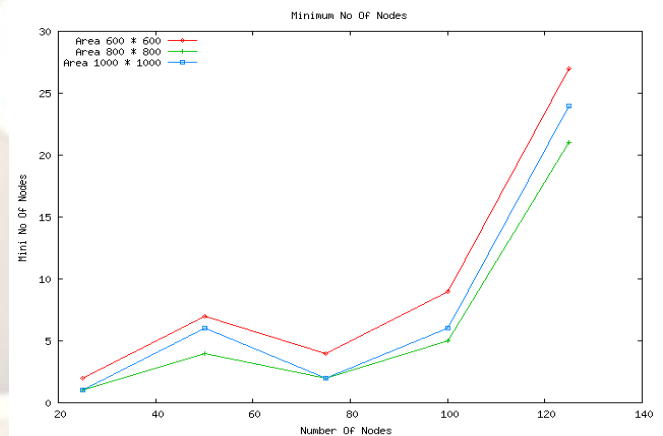| Number of Nodes	95% confidence interval for Maxmum no of neighbors	Relative errors
25	9.20-10.10	0.2
50	18.20-20.20	0.3
75	32.40-34.30	0.2
100	44.20-43.40	0.5
125	60.10-62.20	0.3

Fig. 4. Minimum numbers of neighbours vs. network size with a node speed of 20 m/s
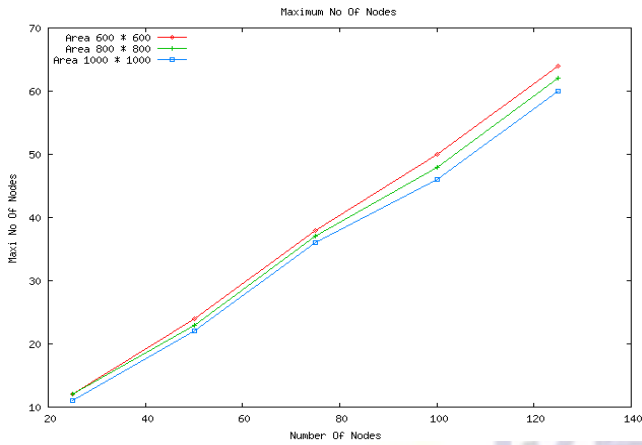
Figure 5. Maximum number of neighbours vs. network size with a node speed of 20 m/s.
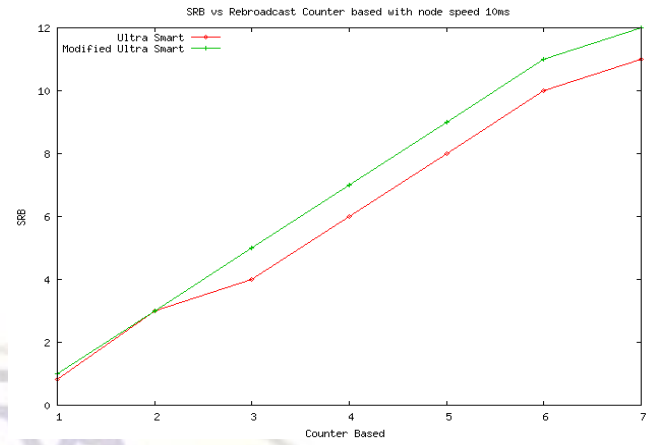

Fig. 6: The SRB vs. the rebroadcast counter based with node speed 10m/s.

The performance of broadcast protocols can be measured by a variety of metrics [1 ,5, 6] A commonly used metric is the number of message re-transmissions with respect to the number of nodes in the network [6]. In this work, we use *rebroadcast savings*, which is a complementary measure and is precisely defined below. The next important metric is *reachability*, which is defined in terms of the ratio of nodes that received the broadcast message out of all the nodes in the network. The formal definitions of these two metrics are given as follows [4, 6].

Saved ReBroadcasts (SRB): Let r be the number of nodes that received the broadcast message and let and t be the number of nodes that actually transmitted the message. The saved rebroadcast is then defined by $(r – t)/r$.

Reachability (RE): is the percentage of nodes that received the broadcast message to the total number of nodes in the network. For useful 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.

We have compared the saved broadcast (SRB) in Ultra Smart counter-Based[15] and our algorithm Modified Ultra Smart counter Based. Fig. 6 shows our algorithm can significantly reduce the number of saved rebroadcast.

Fig. 7 shows the saved rebroadcast (SRB) of the fixed counter-Based, Ultra smart counter based and our Algorithm Modified Ultra Smart counter- Based. The SRB of our algorithm Modified Ultra Smart counter Based is 45% in low-density networks and significantly high in high-density network. Finally, we can see that our algorithm performs the best in various network densities.
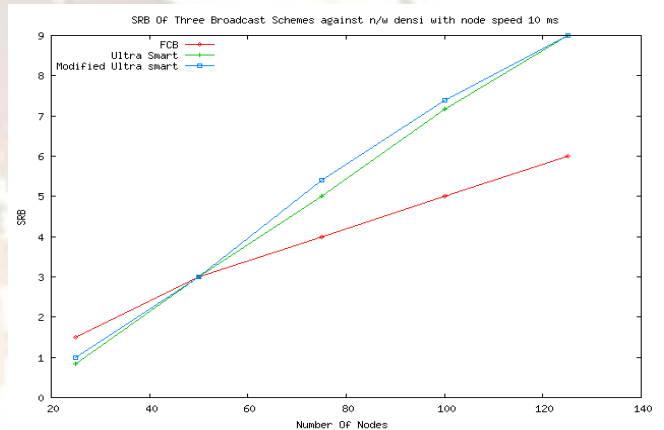

Fig. 7: SRB of three broadcast schemes against network density with node speed 10m/s.
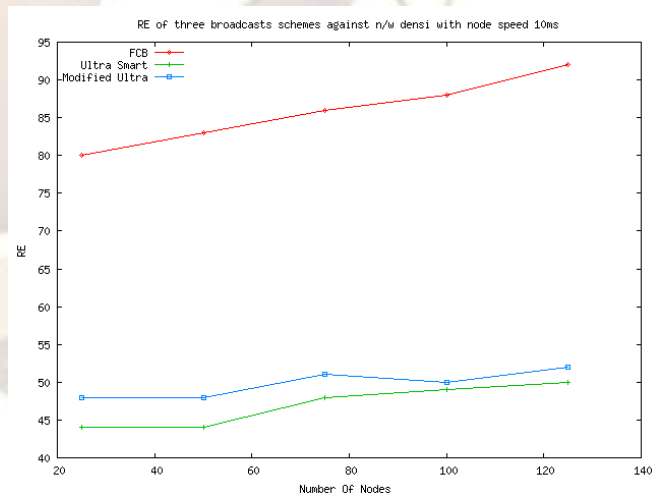

Fig. 8: RE of three broadcast schemes against network density with node speed 10m/s

Fig. 8 shows that reachability increases when network density increases, regardless of what kind of the algorithms is used. The flooding algorithm has the best performance in reachability, reaching nearly

1. The performance of Ultra Smart counter-Based algorithm

shows that the reachability is above 45% in any density of the network. The performance of Modified Ultra Smart counter-Based algorithm shows that the reachability is above 50% in any density of the network .In all network densities, the reachability of our Algorithm performs better than the Ultra smart counter based counter-Based algorithm.

V. CONCLUSION

In MANETs, due to node mobility, neighborhood relationship changes frequently. In order to cope with mobility and have up-to-date neighborhood information, nodes advertise 'Hello' packets periodically. simulation experiments are done in order to characterize node neighborhood in MANETs using 'Hello' packet exchange Simulation results have shown how neighborhood information, that includes minimum and maximum number of neighbors of a given node, have been used to devise a new class of efficient modified ultra smart counter based broadcast algorithms for MANETs. These algorithms enable a given node to dynamically adjust its counter based threshold values depending on whether it is located in a sparse, medium sparse, medium, medium dense or dense network region. Also we investigated the performance merits of the counter-based flooding algorithm.

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