

An Effective Counter Based Adaptive Broadcasting Scheme for Mobile Ad Hoc Networks

¹B. Sundaravadivazhagan and ²P. Jaganathan

¹Renganayagi Varatharaj College of Engineering, Thayalpatti (via), Salavarpatti, India

²PSNA College of Engineering and Technology, Dindigul, India

Abstract: Mobile Adhoc Networks (MANETs) are in desperate need of an effective broadcasting scheme to transmit a data packet from the sender node to destination node and the rest of the network nodes. This paper proposes an effective counter-based broadcasting scheme to accomplish efficient broadcasting by adaptive threshold based on the local density information. The counter identifies nodes with duplicate data packet using threshold values and node removes the redundant message. Probabilistic schemes do not require global topological information of the network to make a rebroadcast decision. In the proposed work, we use random assessment delay (RAD) to evaluate the network congestion level based on the packets received per second at each node. The performance evaluation shows that the proposed broadcasting scheme outperforms the existing methods in terms of reachability, routing overhead and latency.

Key words: MANETs • Flooding • Counter-based • Broadcast storm problem • Throughput • Reachability • Latency

INTRODUCTION

Mobile Ad hoc Networks (MANETs) are irregular and dynamic network which does not necessitate any pre-existing or centralized network infrastructure. MANETs are also called as multi-hop network which uses several mobile nodes as arbitrate nodes in order to receive and forward the transmitted packets through various wireless links. The coverage area of MANETs can be broadened by multi hop services. Thus, the connectivity can also be enhanced. MANETs are becoming increasingly popular as they provide users access to information without any fixed infrastructure. The nodes in a MANET intercommunicate via single-hop and multi-hop paths in a peer-to-peer fashion. Intermediate nodes between a pair of communicating nodes act as routers. Collaborative computing and communications in smaller areas (building organizations, conferences, etc.) can be set up using ad hoc network technologies [1]. Developing support for routing is one of the most significant challenges in ad hoc networks. Node mobility in a MANET results in a highly dynamic network with rapid topological changes, causing frequent route failures.

A good routing protocol for this network environment has to dynamically adapt to the changing network topology [2].

MANETs have become an active research area in recent years. The dynamic nature of MANET makes the routing more difficult than the traditional wireless networks [3, 4]. Thus, broadcasting is a common and important operation in MANETs for route judgment and it could be performed frequently. The simplest solution for broadcasting is blind flooding in which every node rebroadcasts a message when the message is received at the first time [5]. However, lot of articles [6-8] pointed out that blind flooding is improper in MANETs since it brings in lots of duplicate messages and consumes much network resources. Lots of duplicate messages imply serious redundancy in message transmissions and also lead to much contention and collision in mobile wireless networks, which was identified as the broadcast storm problem [9]. Several solutions for reduction of the broadcast storm problem in MANETs had been proposed in the literature [10-12]. The two widely used mechanisms are sender-based and receiver-based. In sender based mechanisms, the originator of a broadcast packet

determines the relay nodes from its neighbors to rebroadcast the packet. Each node in the set of relay nodes further determines its relay nodes when receiving the broadcast packet from the originator and so forth. In receiver-based mechanisms, a mobile node that has received a broadcast packet determines by itself whether or not to rebroadcast the packet.

Ad hoc On-Demand Distance Vector Routing (AODV) is an on-demand protocol used to provide the route discovery and maintenance in a wide variety of network topologies and environments and to achieve improved performance, robustness and better scalability. Route Maintenance is a mechanism used to repair routes when they are invalidated or have broken links, so this error propagated to neighbors that have used this node as their next hop. The main feature of AODV is its ability to use a destination sequence number for each route entry created by the destination for any route information sending to requesting nodes with loop freedom and this requesting node always selects the node with the greatest sequence number. This protocol works on wired and wireless media. In AODV, the neighboring nodes can detect each other's broadcasts by using symmetric links between neighboring nodes. It does not attempt to follow paths between nodes when one of these nodes cannot hear the other one [9].

The probabilistic broadcast includes counter-based, location-based, distance-based and hybrid-based schemes. In counter-based schemes, messages are rebroadcasted only when the number of copies of the message received at a node is less than a threshold value. In the location-based scheme, messages are rebroadcasted only when the additional coverage concept [11] determines the location of the mobile nodes to broadcast. In distance-based scheme messages are rebroadcasted according to the decision made between the relative distance of mobile node and the previous sender. In cluster-based scheme, the network is divided into number of clusters; each cluster has a single cluster head and several gateways. Each cluster head, in turn, acts as a source for rebroadcast within its own cluster and the gateways can communicate with external clusters and are responsible for transmitting the broadcast message externally. Hybrid schemes [12] combine between the advantages of probabilistic and counter-based schemes to achieve the performance improvement. The second category is known as a deterministic broadcast scheme and includes multipoint relaying [13], node-forwarding [14], neighbor elimination [15] and clustering [16]. In this

paper, we propose an effective counter-based broadcasting scheme to accomplish efficient broadcasting by adaptive threshold based on the local density information.

Literature Review: Tseng *et al.* (2001) suggested counter-based scheme and distance-based scheme to solve the broadcast storm. It has been demonstrated that, the additional coverage (AC) of the new rebroadcast is lower, when the distance d between two vehicles is short [16]. For larger d , the additional coverage will also be larger. Location-based scheme is somehow similar to the distance-based scheme, but it requires more precise locations for the broadcasting vehicles. Traditional flooding [17] schemes suffer from the problem of redundant message reception. The same message is received multiple times by every node, squanders 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 neighbours. Probability-based scheme is a very simple way of controlling message floods. Every node retransmits with a fixed probability. In the area-based scheme, a node determines whether to rebroadcast a packet or not by calculating and using its additional coverage area. The neighbour knowledge scheme maintains neighbour node information to decide who should rebroadcast. This method requires mobile hosts to explicitly exchange neighbourhood information among mobile hosts using periodic "HELLO" packets. The neighbour list at the present host is added to every broadcast packet. When a packet arrives at the neighbour of the present host, every neighbour compares its neighbour list with the list recorded in the packet. It rebroadcasts the packet if not all of its own neighbours are included in the list recorded in the packets. The length of the period affects the performance of this approach. Very short periods could cause contention or collision while too long periods may debase the protocol's ability to deal with mobility.

The probabilistic approach has been proposed in [10,18] as a mechanism to reduce redundant rebroadcast messages. Probabilistic approach works as follows: when

receiving a packet, each node forwards the packet with probability p . Ni *et al.* [18] have proposed a probability-based scheme to reduced the redundant rebroadcast packets like flooding and counter-based schemes. Every node in flooding is rebroadcast with a fixed probability P . On the other hand, counter-based scheme is proposed with additional coverage of each rebroadcast when receiving n redundant messages of the same packet. Zhang and Agrawal in [19] proposed a Dynamic probabilistic broadcast scheme as a combination of the probabilistic and counter-based approaches. The scheme is implemented using AODV protocol. Cartigny and Simplot in [11] proposed the probabilistic scheme as a combination of the advantages of probability-based and distance-based schemes. A counter-based scheme which works as follows: when receiving a packet, the node initiates a counter and a timer. The counter is increased by one for each received redundant packet. When the timer terminates, if the counter is larger than a threshold value, the node will not rebroadcast the packet; otherwise, the node will broadcast it.

To minimize the broadcast storm problem, reference [18] suggests two directions: to restrain redundant rebroadcasts and to make a distinction between the timing of rebroadcasts. In counter based scheme, when c reaches a predefined threshold C , the host is inhibited from rebroadcasting this packet because the additional coverage could be low[19]. It provides significant saving when a small threshold is used. A larger threshold will provide less saving in a sparse network but behave almost like flooding. In location based scheme, a predefined threshold is used to determine whether the receiving host should rebroadcast or not. Since added accurate information is used, the location-based scheme can attain better performance in terms of both reachability and the quantity of saving than the counter-based scheme. However, one problem with the schemes in is that the threshold used is a predefined fixed value. These schemes are referred to as fixed-threshold solutions. This poses a dilemma between reachability and the amount of saving on rebroadcasts as the host distribution of the MANET changes [20].

The Proposed Scheme: Conventional counter based on-demand route detection methods in MANET employ simple flooding method, where a mobile node simply rebroadcasts received packets until a route to a particular destination node is

established. Our scheme is used to reduce the contention and collision problems associated with conventional counter based approaches. It achieves efficient broadcasting by adaptive threshold with a predetermined forwarding probability ' p ' which can be fixed based on the local density information. The counter identifies nodes with duplicate data packet using threshold values and node removes the redundant message. This probabilistic approach does not need global topological information of the network to make a rebroadcast decision. Here every node is allowed to rebroadcast a message. The use of this scheme is to facilitate the mobile nodes to rebroadcast a message if the number of received duplicate packets is less than a threshold by taking in to account the status of the node density. In a network of random distribution of mobile nodes as in MANETs, there are regions of varying degrees of node density. Therefore, the forwarding probability p should be set dynamically to reflect local topological characteristics of a given node; e.g. whether the node is located in a sparse or dense region [21]. Consequently, it is critical to identify and categorize mobile nodes in the various regions of the network and appropriately adjust their forwarding probabilities. To achieve this, the node densities at various regions in the network are first determined using the neighbourhood information collected at nodes located in those regions. The neighbourhood information is collected using periodic exchange of "hello" packets to construct a 1-hop neighbour list at each node in the network. Using the node densities at various regions in the network, two new adjusted probabilistic route discovery approaches are suggested in this paper. The algorithm for the proposed probabilistic based adaptive threshold scheme is shown in Fig. 1.

The use of a rebroadcast probability stems from the fact that packet counter value does not necessarily correspond to the exact number of neighbours of a node, since some of its neighbours may have suppressed their rebroadcast according to their local rebroadcast probability. Therefore to adapt T_{max} to congestion levels, each node keeps track of the number packets received per second. Thus, each host will use a threshold C depending on its current value of n to determine whether to rebroadcast or not. There should be a neighbor discovery mechanism to estimate the current value of n . This can be achieved through periodic exchange of 'HELLO' packets among mobile nodes. Each host now executes the following steps

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protocol receiving ()
1. On hearing a broadcast packet m at node X;
2. Get the Broadcast ID from the message;
   n1 minimum numbers of neighbor, n2 maximum number of neighbor, all
   are
   threshold values;
3. Obtain the number of neighbors of node Xj;
4. If packet m received for the first time then
5. Get the number of neighbours at node Nj at node j
6. Get the upper and lower averages of number of neighbours max and min
7. if nj<min
   Set broadcast probability p=p1
8 else if min < nj < max
   Set broadcast probability p=p2
9 else if nj>max
   Set broadcast probability p=p3
10. Generate a random number rd between [0, 1]
11. If rd>p
   Send packet
   Else
   Drop packet
14. Wait for a random number of slots until the transmission is actually starts.
15. End while
16. Increment the counter-threshold
17. If (counter_threshold< threshold) Go to 11
18. Else exit algorithm
    
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Fig. 1: Algorithm for the proposed density based adaptive threshold scheme

Each data point represents an average of 20 different randomly generated mobility scenarios with 98% confidence interval. The error bars in the graphs represent the upper and lower confidence limits from the means and in most cases they have been found to be quite small. For the sake of clarity and tidiness, the error bars have not been included in some of the graphs. We evaluate the broadcast schemes using the following performance metrics:

- Reachability - measures the proportion of nodes which can receive a broadcast packet. A mobile host will miss a packet if all of its neighbours decide to suppress rebroadcasts.
- Saved Rebroadcast (SRB) - This is defined as $(r - t)/r$, where r and t are the number of nodes that received the broadcast message and the number of nodes that transmitted the message respectively. a mobile host rebroadcasts every routing request packet if received for the first time. Consequently, there are $N-1$ possible rebroadcasts, where N is the total number of mobile nodes.
- End-to-end delay - is the average time difference between the time a data packet is sent by the source node and the time it is successfully received by the last node in the network.
- Routing overhead -the total number of route request packets transmitted during the simulation time. For packets sent over multiple hops, each transmission over one hop is counted as one transmission.

Performance Analysis: In order to verify the outcome of the proposed adaption scheme, numerous simulations have been performed. We compare the proposed scheme with counter-based and AODV methods. The performance analysis is based on the assumptions widely used in literature [2, 20].

- All nodes are identical and equipped with IEEE 802.11 transceivers with the same nominal transmission range.
- All nodes participate fully in the protocol of the network. In particular each participating node should be willing to forward packets to other nodes in the network.
- Packets may be lost or corrupted in the wireless transmission medium during propagation. A node that receives a corrupted packet can detect and discards the packet.
- All mobile nodes are homogeneous (i.e. wireless transmission range and interface cards are the same)

For a given topology scenario, if N is the number of nodes in the network and N_i is the number of neighbours at a node x_i at a particular time instant, the average number of neighbours at a node in the network at that time instant is defined by the relation. The simulation scenarios consist of three different settings, each specifically designed to assess the impact of a particular network operating condition on the performance of the protocols. First, the impact of network density or size is assessed by deploying 25, 50 and 120 mobile nodes. The second simulation scenario investigates the effects of offered load on the performance of the routing protocols by varying the number of source destination pairs (flows for short) over the range 1, 5, 10, 15 flows for each simulation scenario. The last set of simulations evaluates the performance impact of node mobility by varying the maximum node speed of 55 mobile nodes over the range 10, 15, 20 and 25 m/s in a fixed area

After the node reaches its destination, it again stops for a pause-time interval and chooses a new destination and speed. This cycle repeats until the simulation terminates. The simulation is allowed to run for 800 seconds for each simulation scenario. Other simulation parameters that have been used in our experiment are shown in Table 1.

Like the previous studies, the offered traffic load simulation is done by changing the number of Constant Bit Rate (CBR) connections. This CBR connection ensures that all cells in a transmission are maintained from end to end. This service type is used for voice and video

Table 1: Simulation parameters.

Simulation Parameter	Parameter Value
Simulator	NS-2 (v.2.29)
Transmission range	120 meters
Bandwidth	2 Mbps
Interface queue length	55
Packet size	512 byte
Traffic type	CBR
Packet rate	10 packets/sec
Topology size	600 x 600 m ²
Number of nodes	20,30...55
Number of trials	40
Simulation time	800 sec
Maximum speed	20 m/s
Counter threshold ©	5
RAD Tmax	0.01 seconds

transmission that require little or no cell loss and rigorous timing controls during transmission. The numbers of CBR connections that are considered in the experiments are 10, 20, 30 and 55 for the number of nodes. The maximum speed 20 m/s is chosen to study the effects of traffic load in the network with high speed. When the speed is high the traffic load is concentrated on some nodes so the congestion is occurred.

Fig. 2 shows the results of the normalized routing load vs. the network sizes (number of connections) for all the three schemes. Apparently, this figure shows that increases in connections tend not to lead to noticeable increase in the NRL using our proposed scheme. When the traffic load increased, there exist many connections between any nodes used to reach to the destination, so we choose one of these connections. Most of the generated data packets and connections are dropped resulting from collisions and contention. Nevertheless, our proposed scheme will decrease the NRL over the traffic load percentage against other schemes and shows better performance up to 30%. This is because the flooding sends the packets to all nodes continuously without checking if these nodes receive this packet in previous time; thus this causes a collision and contention in the network leading to additional load on the network.

Fig. 3 represents the delays of all schemes for different traffic loads. The delay is increased as the traffic load grows. The number of packets transmitted on the network has a considerable impact on delay. When the number of CBR connections increases the number of collisions, contentions and redundant rebroadcast packets grows. Thus, this leads to more retransmissions of packets towards the destination and, hence, resulting in growing delay. Fig. 3 shows that flooding incurs higher end-to-end delay. This is owing to the higher number of

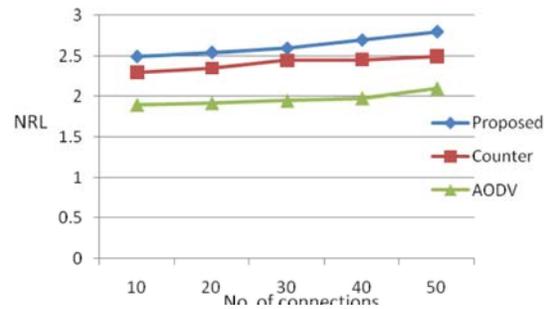


Fig. 2: Normalized routing load vs. the network sizes

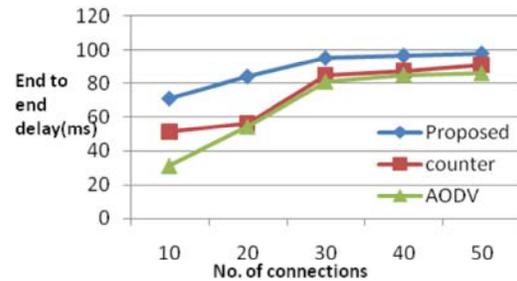


Fig. 3: End-to-end delay Vs network size

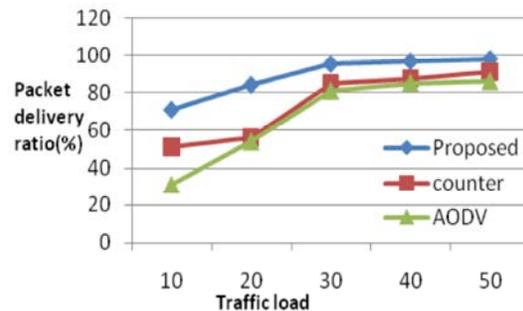


Fig. 4: Packet delivery ratio Vs traffic load

redundant rebroadcasts of RREQ packets with collisions and contention caused by many RREQ packets that fail to reach the destination.

Fig. 4 represents the PDR for all schemes in this study. This figure shows that our proposed scheme has a higher value of PDR compared with two counter-based and flooding. Packet delivery ratio increases when increasing the number of connections for the following reason: the more the network connections, the better and more available shortest paths towards destination. This implies that there are more connections to connect two nodes offering a better transmission in each area. Hence, there is a greater chance that a broadcast retransmission occurs successfully, resulting in an increased delivery ratio.

CONCLUSION

This work proposed an effective density based broadcasting scheme to accomplish efficient broadcasting by adaptive threshold that can be fixed based on the local density information. The counter identifies nodes with duplicate data packet using threshold values and node removes the redundant message. The proposed approach dynamically sets the value of the rebroadcast probability for every host node according to its neighbour's information. Simulation results disclose that this simple adaptation minimizes end-to-end delay to 44ms and maximizes delivery ratio to 97.75% and thus achieves superior performance in terms of reachability, routing overhead and latency over the other schemes.

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