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RBND: A Novel Hybrid Broadcasting Technique to Reduce Routing Overhead in MANET

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Abstract - Mobile Ad hoc Network (MANET) is a cluster of wireless mobile nodes that are liberated to stir in any directions at any speed. This nature of manet leads to link splintering, which in succession leads to route discovery, hence overhead, is created in the network. Broadcasting is a basic and effective data propagation problem, where a portable node blindly rebroadcasts the first received route request packet unless it has a direction to the destination, and therefore it causes the broadcast storm dilemma. The aim of this research is to design an efficient broadcasting method for MANETs that unite the features of fixed probability, neighbour knowledge based method and some other broadcasting methods in order to diminish the broadcast storm problem adverse effects without sacrificing. This new broadcasting method known as Rebroadcast Based on Node Density (RBND); it works on the principle of node density. In addition this new broadcasting method also reduces the overhead caused by the wrecked links and speeds up the discovery period. The obtained simulation results authenticate the anticipated approaches.

Keywords - MANET, broadcast storm problem, RBND, routing overhead.

I. INTRODUCTION

A MANET [21] as shown in Fig 1, is a cluster of wireless moveable devices also known as nodes forming a impermanent network without the assist of any fixed infrastructure or centralized administration [21, 16]. The communication between the nodes takes place over a wireless medium, where the communication capability of each node within a network is restricted by its transmission range, i.e., two nodes can communicate directly with each other only if they are within the same transmission range. And the nodes or devices that are not within the transmission ranges of each other takes the help of some intermediate nodes for their communication. Hence in MANET a node operates not only as a host but also act as a router that can send and receive packet as well as forward packets to other nodes.

Fig 1: A Mobile Adhoc Network[21]

Due to this dynamic nature and recurrent topology changes in adhoc network, mobile nodes have to exchange several messages to communicate with each other. As a result, broadcasting is frequently used in adhoc networks. In many MANET applications, for instance broadcasting of aid information to manage relief actions in disaster field, resource discovery or advertisement in several routing protocols [20,17], or sending an error message to erase invalid routes; broadcasting used as a basic building block for providing important control and route establishment functionality. Therefore, any advance in the process of broadcasting would have a direct benefit for many important MANET applications.

Broadcasting is the process of disseminating packets from a given source node to all other nodes within the network [7-16]. The simplest method of broadcasting is flooding, in which each node in the network forwards the every unique packet exactly once. Although flooding method ensures the assured delivery of a given packet to every node in the network, but this method generates many redundant transmissions in the network [15- 17]. In a dense network, more retransmission redundancy would be introduced that generates the significant transmission contention and collision. Such a phenomenon is referred to as broadcast storm dilemma [13] and leads to a collapse in the operation of the entire network.

There has been significant research efforts on mitigating the transmission severance associated with flooding [14]. Nevertheless, most of the anticipated probabilistic methods are insufficient in reducing the number of redundant broadcast while still guarantees that majority of nodes receive the packet. In some cases, this method requires global network topological information [12-11] or uses the supplementary hardware devices for distance measurement or location identification [14] in order to diminish the redundant transmissions. Therefore, a broadcast method that can lessen the broadcast storm dilemma would be highly enviable.

II. RELATED WORK

In general there are two categories of routing protocols for MANETs; namely proactive protocols, i.e., ones that try to preserve up to date routing information at each node[4]–[21], and reactive ones, which gather the necessary routing information only when it becomes explicitly needed to carry on an actual session [21]–[20]. Israat Tanzeena Haque et. al.[1] analyze and evaluate the most commonly used routing protocols in mobile ad hoc networks. In particular, the author; consider routing and control overheads, storage requirements, and network setup costs of these protocols to see how they fit in manet networks with nodes that have insufficient resources. The focus of the author is to select the pioneer and broadly used methods from each class and analyze their routing overheads. The Xin et. al. [3] anticipated a new protocol called NCPR based on neighbour coverage in order to lessen the routing overhead in MANETs. This neighbour knowledge takes in additional coverage ratio and connectivity factor, which is used to resolve the rebroadcast probability. The authors projected a new method to dynamically calculate the rebroadcast delay, which is used to conclude the forwarding order and more effectively develop the neighbour coverage knowledge. Zehua Wang et. al.[2] proposes a lightweight proactive source routing (PSR) protocol. PSR can maintain additional network topology information than distance vector (DV) routing to assist source routing, even though it has overhead than conventional DV based protocols. The anticipated broadcast method in this letter has an important role in the performance of routing protocols in adhoc networks.

This research argues that it is possible to develop an efficient broadcasting methods that can significantly improves the network performance and degrades the effect of broadcast storm problem[13] without sacrificing reachability or requiring any additional hardware while at the same time achieving good performance levels in terms of collision rate (i.e. the total number of packets dropped as a result of collisions per simulation time) and end-to-end delay (i.e. the impediment a broadcast packet experiences to arrive at the node in the network). The proposed broadcast method has an important role in the performance of routing protocols in Ad Hoc Networks. We named this new broadcasting method as Rebroadcast Based on Node Density (RBND); because it works on the principle of node density.

The main objectives of this research work are summarized as follows:

- To design a new broadcasting methods for reducing a routing overhead in MANET.
- To enhance the packet delivery ratio and to diminish the end to end delay.
- To analyze and validate the obtained results through simulations.
- To compare the new proposed protocols with the existing protocols with respect to different network parameters.

III. PROPOSED METHODOLOGY

In literature, a number of research groups have anticipated more efficient broadcasting techniques in order to lessen the number of retransmissions while attempting to make sure that a broadcast packet is delivered to each node in the network. There are some limitations of existing broadcasting methods:

Simple flooding causes a high network routing load in the network because of the broadcast storm dilemma, and as a result consumes high energy. Probabilistic flooding method has been proved to be more capable than the simple flooding method. However, the main challenge in the probabilistic method is to find the best possible probability P of the forwarded packets. Area based methods bear from nodes' mobility since nodes should update their locations periodically which causes an additional overhead. Neighbor knowledge method uses information on neighboring nodes in order to gather the nodes in clusters. This method has reduced overhead for low mobility networks; though it is not fit for high mobility networks. Most neighbor knowledge methods furthermore insert a list of neighbor's IDs, which increases the overhead in the request packets.

A hybrid broadcast method for adhoc network is anticipated; we named this new method as *RBND*. The main intention is to combine different flooding methods in order to solve the broadcast storm issue encountered by the simple flooding method. For this reason, the density of nodes is taken into account using a density metric called as expansion metric. In addition, in order to lessen the wrecked links due to mobility of nodes and increasing dissimilarity among the intermediary nodes, a forwarding zone principle is included in the anticipated methods. The anticipated approaches have been implemented and compared with existing broadcasting methods.

IV. REBROADCAST BASED ON NODE DENSITY

We named this new broadcasting method as RBND (Rebroadcast Based on Node Density). The word expansion metric, which discriminates the density of nodes in diverse areas of the deployed scenario, is defined to quantify the neighbourhood information. In addition, a forwarding zone principle has been defined to manage the forwarding probability. The forwarding zone principle has two major objectives:

- To lessen the control messages due to wrecked links, and
- To perceive the dissimilarity among the forwarding nodes and pick the most unlike nodes.

As a way of addressing the issues with neighbour knowledge methods, the anticipated method eradicates the need for the nodes to cache a node's ID. They only calculate the number of 1-hop and 2-hops neighbours in order to compute the expansion metric, and the request packets include only the expansion metric.

The terminologies used in the proposed method are:-

- *Node's degree (d):* It is the number of neighbors of a known node.
- *2-hops node's degree (d2h):* It is the number of neighbors of a known node's neighbors. This metric signifies the no. of neighbors which are 2 hops away from the node.
- *Expansion metric (E):* It is a density metric which concludes how dense the 2 hops neighborhood of a node is. It is intended as follows:

$$E = D_{2h}/D \qquad \text{Equation (1)}$$

In this method, when the nodes assess the equation (1), if an intermediary node has a high value for E, it will mean that its 2 hops neighborhood is opaque. On the other hand, if the value of E is low, then its 2 hops neighborhood is not dense. Therefore, it can be safely concluded that the difference between two intermediate nodes' E-values represents the distinction in densities between the nodes' 2 hops neighborhood. As mentioned before, in dense areas, the value of optimum probability P should be condensed because of the redundancy of control packets. As a result, the distinction among the two values of E in a broadcast path could be measured as the metric that indicates whether the value of P should be enlarged or reduced along the broadcast path. In this letter the value of probability P is adjusted hop by hop depending on the value of expansion metric E. The forwarding probability can be articulated as:

$$P(E_t,E_{t-1}) = Pi+Pd(E_t, E_{t-1}) \text{ if } E_t < E_{t-1}$$
$$P(E_t, E_{t-1}) = Pi-Pd(E_t, E_{t-1}) \qquad \text{if } E_t > E_{t-1}$$
$$P(E_t, E_{t-1}) = Pi \qquad \text{if } E_t = E_{t-1} \qquad \text{Equation (2)}$$

Where $P_d(E_t, E_{t-1})$ is the density reliant probability and P_i is the primary value of the probability for forwarding an incoming packet.. E_t is the expansion metric at the intermediate nodes. In order to clarify the anticipated method, let us consider a sample network, as shown in Fig 2:

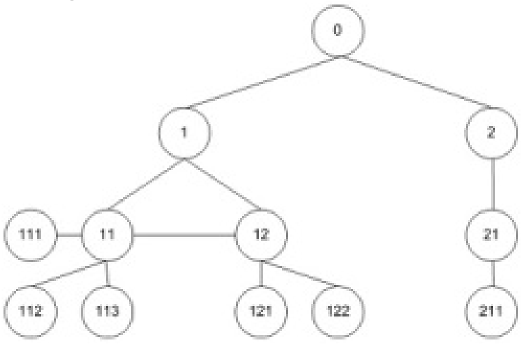

Fig 2: A Sample Network with Different Degrees of Connection

The node 0 is the source node in Fig 2. A node's degree in its 2-hops neighbourhood from the source node can be articulated as below:

D(0) = [1,2]=2
D(1) = [0,11,12]=3
D(2) = [0,21]=2
D(11) = [1,12,111,112,113]=5
D(12) = [1,11,121,122]=4
D(21) = [2,211]=2

likewise, the 2-hops degrees for the source node 0, and the 1-hop neighbours 1, and 2 are specified by the following expressions:

D2h(0) = [12,21,11]=3
D2h(1) = [2,12,11,111,112,113,122,121]=8
D2h(2) = [1,211]=2

The Expansion Metrics for the nodes 0, 1, and 2 will be premeditated using equation (1) and are given below:

$$E(0) = 3/2 = 1.50$$
$$E(1) = 8/3 = 2.66$$
$$E(2) = 2/2 = 1.0$$

Applying the above values for E(0), E(1) and E(2) in equation (2), the forwarding probability for nodes 1 and 2 are specified by:

$$P(1) = P_i - P_d$$
$$P(2) = P_i + P_d$$

As a result, each node will alter its forwarding probability anticipating the network's structure from its local point of view. However, in the above approach, the neighbours located closer to the broadcast node will not discover new areas since their transmission ranges are expected to cover the same area. Hence, the anticipated density dependent approach has been enhanced by taking the distance between the nodes into account. Larger the distance among the two nodes, the higher the dissimilarity among the nodes' neighbours is. Tough, mobile bordering nodes are likely to get out of the node's transmission area [20], and thus will cause broken links. Whenever a wrecked link occurs a new discovery phase should be started which in turn will enlarge the use of control messages. Therefore, an enhanced forwarding zone principle is anticipated in this letter to improve the connectivity. If the intermediate node is located outside the forwarding region, the probability of forwarding the incoming packet is 0, Otherwise, the value of P is calculated using equation (2).

This method uses simple flooding algorithm during the discovery period to find a communication path from the source to the destination node. Several modifications have been made to the conventional AODV method in order to contain the expansion metric and the forwarding zone approach. The number of neighbours of a known node has been included in the HELLO packets. The nodes do not require collecting its entire neighbours' IDs, they only need the total number of the neighbours.

The anticipated approach uses only 5-6 extra bits within the hello packets to include this information in networks with more than 100 nodes. This characteristic makes the anticipated approach lighter than the other neighbour knowledge methods [4]. The request packets (RREQs) contain the node's expansion metric. When an intermediary node receives the RREQ, it determines its expansion metric and compares it with the value enclosed in the RREQ in order to alter the value of P using equation (2).

The formal description for implementing the proposed protocol "Rebroadcast Based on Node Density" in shown below:

Algorithm: RBND

Definitions:

Node's degree (d): It is the number of neighbors of a known node.

2-hops node's degree (d2h): It is the number of neighbors of a known node's neighbors.

Expansion metric (E): It is a density metric which concludes how dense the 2 hops neighborhood of a node is.

Step 1: Initially find the *node degree (d)* of each node in the network.

Step 2: Based on the node degree of each, find the *2-hop node's degree (d2h)*.

Step 3: Calculate the *Expansion Metric (E)*:

$$E = d_{2h}/d$$

//if an intermediary node has a high value for E, it means that its 2 hops neighbourhood is opaque. On the other hand, if the value of E is low, then its 2 hops neighbourhood is not dense.

Step 4: Calculate the *forwarding probability (P)*:

$$P(E_t, Et_{-1}) = P_i+P_d(E_t, E_{t-1}) \text{if } E_t < E_{t-1}$$
$$P(E_t, E_{t-1}) = P_i-P_d(E_t, E_{t-1}) \quad \text{if } E_t > E_{t-1}$$
$$P(E_t, E_{t-1}) = P_i \quad \text{if } E_t = E_{t-1}$$

//Where $P_d(E_t, E_{t-1})$ is the density reliant probability and P_i is the primary value of the probability for forwarding an incoming packet. E_t is the expansion metrics.

Step 5: Each node will alter its *forwarding probability*, and will broadcast the RREQ packet.

Step 6: End

V. PROTOCOL IMPLEMENTATION AND PERFORMANCE EVALUATION

A. Protocol Implementation

In the following sections we will discuss the approach in validating our model, the tools essential for simulating the network environment, the improvements seen and the concessions made. In recent years, several discrete event network simulation tools have been suggested for performance analysis of MANETs . The commonly used network simulators are *NS-2* [22], *GloMoSim* [19], *QualNet* [24], *OMNET++* [5] and *OPNET* [23]. In order to assess the performance of the system, we simulated a model of MANET on the NS2 (Network Simulator 2) simulator.

B. Simulation Environment

The intact simulations are carried out using ns – 2.35 network simulator which is a discrete event driven simulator developed at UC Berkley as part of the VINT project. The objective of the NS2 is to sustain research and education in networking. It is suitable for designing new protocols and traffic evaluations.

C. System Parameters

The results are generated according to the given parameters:

TABLE 1 SYSTEM PARAMETERS

Sr. No.	Simulation Parameter	Value
1	Simulator	NS – 2 version 2.35
2	Channel Type	Channel/Wireless Channel
3	Radio Propagation Model	Propagation/Two Ray Ground
4	Network Interface Type	Phy/WirelessPhy

5	MAC Type	Mac/802_11
6	Interface Queue Type	Queue/DropTail/PriQueue
7	Link Layer Type	LL
8	Antenna Model	Antenna/OmniAntenna
9	Max Packet in IFQ	200
10	Number of Mobile Nodes	10,20,30,40,50
11	Routing Protocol	AODV
12	X Dimension of Topography	600
13	Y Dimension of Topography	600
14	Time of Simulation End	30
15	Traffic Type	CBR
16	Packet Size	1024 bytes

D. Performance Metrics

The performance of the new broadcast proposal is measured by using the following performance metrics:

1. *MAC Collision Rate:* The average number of packets including route request (RREQ), route reply (RREP), route error (RERR), and CBR data packets dropped resulting from the collisions at the MAC layer per second.
2. *Normalized Routing Overhead:* The ratio of the total packet size of control packets (i.e. RREQ, RREP, RERR, and Hello) to the total packet size of data packets delivered to the destinations. For the control packets to be sent over multiple hops, every single hop is counted as one transmission.
3. *Packet Delivery Ratio:* It is considered by dividing the number of packets received by the destination during the number of packets originated by the application layer of the source i.e. CBR source. The greater the delivery ratio, the more complete and accurate is the routing protocol.
4. *Average End-to-End Delay:* End to end delay shows that how long it takes for a packet to travel from the CBR sources to the application layer of the destination. It describes the average data delay an application or a user practice when transmitting data.

E. The Result

In this section the result obtained from the proposed protocol are compared with the existing protocols.

TABLE 2 NCPR VS RBND

PARAMETERS	NCPR	RBND
Number of Nodes	10	10
MAC Collision Rate	68.80%	15.24%
Packet Delivery Ratio	31.19%	84.75%
End to End Delay	0.84ms	0.13ms
Normalized Routing Load	0.31	0.26

F. Graph

The result obtained after the simulation of the anticipated protocol can also be analyzed through graphs based on various performance metrics to the number of nodes.

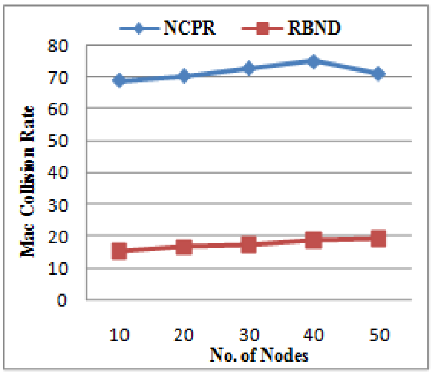

Fig 3: MAC Collision Rate

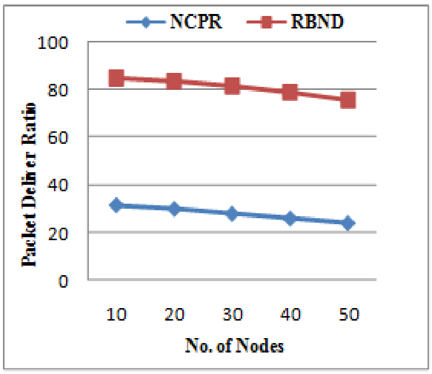

Fig 4: Packet Delivery Ratio

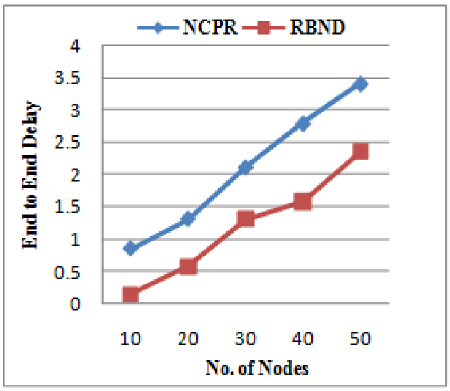

Fig 5: End to End Delay

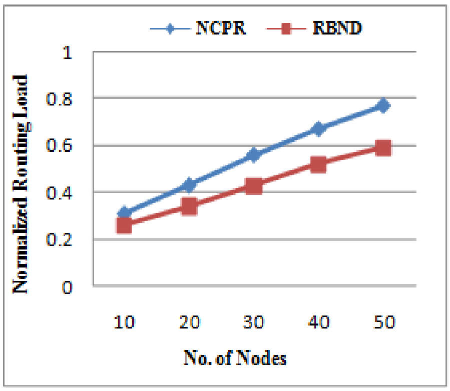

Fig 6: Normalized Routing Load

VI. CONCLUSION AND FUTURE ENHANCEMENT

A. Conclusion

The anticipated broadcast method in this letter has an important role in the performance of routing protocols in manet . Simple flooding is definitely unproductive for manet. Probabilistic flooding improves the performance of simple flooding to some point. Conversely, the value of probability should be adjusted to the situation of the network. Therefore a new protocol named RBND is proposed with the aim to diminish the overheads in mobile adhoc networks using an adaptive probabilistic flooding method based on neighbour knowledge and a forwarding zone principle. The term expansion metric which discriminates the density of nodes in different areas of the deployed scenario is defined to evaluate the neighbourhood information. In addition, a forwarding zone principle has been defined to control the forwarding probability. Also the anticipated approach does not hindrance the communications like some broadcasting schemes, as the nodes start to retransmit instantly after receiving the incoming request. In addition it also decreases the overhead caused by the wrecked links and speeds up the discovery period. The obtained simulation results authenticate the anticipated approaches.

B. Future Enhancement

We are currently participating in a combined experimentation to dig out real life traces of mobility models. So, the anticipated protocol will be evaluated using a real trace mobility model in our next stage of research work.

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