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MINIMUM DELAY BASED ROUTING PROTOCOL IN MANET

Abhishek Jain, Ashish Jain, Rohit Thete, Akshay Shelke, Harshada Mare
BE, Department of Computer Science,
MIT Academy of Engineering,
Pune, India
abhi.jain2210@gmail.com, ashishomatic@gmail.com, rt90thete@gmail.com, shelkeakshay@gmail.com, harsha_mare@hotmail.com

Prof. S.A. Jain
Asst. Professor, Department of Computer Science, MIT Academy of Engineering,
Pune, India
sajain@comp.maepune.ac.in

***Abstract*—Broadcasting is a fundamental and effective broadcasting technique in mobile ad hoc networks (MANET). Simple flooding technique is used in conventional ad hoc protocols for route discovery in which the mobile node blindly rebroadcast the packets until route to destination is established. But this causes redundant transmission of control packets leading to collision and contention in network. This problem is referred as broadcasting storm problem. To overcome this problem, neighbor coverage based probabilistic rebroadcasting protocol is used which combines the merits of neighbor coverage knowledge and probabilistic method. In order to effectively exploit the neighbor coverage knowledge, rebroadcast delay is used to determine the forwarding order and then we calculate rebroadcast probability by combining additional coverage ratio and connectivity factor. This approach can significantly reduce the end-to-end delay by reducing the routing overhead and increasing packet delivery ratio to improve routing performance of the network.**

***Index Terms*—MANET, Rebroadcast Probability, Control Packets, Neighbor Coverage Knowledge, Broadcasting, Routing Overhead.**

I. INTRODUCTION

MANET is a self-configuring, infrastructure-less network of mobile nodes which are connected without wires. But due to high mobility of nodes, link breakages may occur which will lead to frequent path failures and route discoveries. This increases the overhead of routing protocols, effectively increasing end-to-end delay and reduces the packet delivery ratio [1]. So reducing the routing overhead in MANET is essential problem.

In conventional ad hoc on-demand distance vector routing protocol (AODV) [2] method, simple flooding is used for route discovery where nodes blindly rebroadcast received route request (RREQ) packet until route to the destination is established. While this method has many advantages, but due to redundant retransmission causes broadcast storm problem [3]. Some methods have been proposed to optimize broadcast problem and Williams and Camp [4] has categorized broadcasting protocol into four classes: "simple flooding, probability-based methods, area based methods and neighbor knowledge methods."

Since limiting the number of rebroadcast can effectively optimize the broadcasting [3]; and the neighbor knowledge methods perform better than the area-based method and the probability based method [6]. Combining merit of neighbor knowledge and probabilistic based method we propose neighbor coverage based probabilistic rebroadcast (NCPR) protocol. So, (1) In order to effectively exploit the neighbor coverage knowledge, rebroadcast delay is used to determine the forwarding order, (2) with the help of uncovered neighbor (UCN) set, additional coverage ratio and connectivity factor is calculated the determine the rebroadcast probability. Additional coverage ratio is a ratio of the covered node by single broadcast to the total number of neighbor and connectivity factor is relationship of network connectivity and number of neighbor of given node.

The rest of this paper is organized as follows: Section 2 describes the proposed system and implementation Detail. Section 3 is Simulation Results. In Section 4 we have concluded with our observations.

II. PROPOSED SYSTEM

In this section, first calculate rebroadcast delay to determine it forwarding order and set the timer according to the delay. Second, calculate rebroadcast probability with the help of neighbor knowledge method by multiplying additional coverage ratio and connectivity factor, which requires that each node needs its 1-hop neighborhood information.

A. Uncovered Neighbor Set and Rebroadcast Delay

When source node *S* send RREQ packet to the node n_i, it attaches its neighbor list along with RREQ packet. Node n_i uses the neighbor list in the RREQ packet to estimate the number of neighbor nodes that are not covered by RREQ packet of node *S*. The *uncovered neighbor set* $U(n_i)$ of node n_i is given as:

$$U(n_i) = N(n_i) - [N(n_i) \cap N(S)] - \{S\} \qquad (1)$$

Where $N(n_i)$ and $N(S)$ are neighbor set of node *S* and n_i. *S* is the node which send the RREQ packet to node n_i.

But due to broadcasting characteristics, node may receive duplicate RREQ from its neighbor. So when node receives RREQ packet, a rebroadcast delay is set according to the neighbor list in RREQ packet and its own neighbor list. The *rebroadcast delay* $T(n_i)$ is defined as follows:

$$T_r(n_i) = 1 - \frac{|N(S) \cap N(n_i)|}{|N(n_i)|}$$
$$T(n_i) = MaxDelay * Tr(n_i) \qquad (2)$$

Where $T_r(n_i)$ is delay ratio of node n_i and *MaxDelay* is a small constant delay in the network.|.| is the number of elements in a set.

The rebroadcast is used to determine the forwarding order. The node which has mode common node with the sender, according to Eq. 2, will have lower delay. Therefore, this rebroadcast delay enables the information that the nodes have transmitted the packet, spread to neighbors more quickly. This is performed by using the Neighbor Knowledge Probabilistic Rebroadcast (NKPR) protocol based on the neighbor knowledge method. After determining the rebroadcast delay, the node can set its own timer.

B. Neighbor Knowledge and Rebroadcast Probability

The node which has larger rebroadcast delay may receive RREQ packets from nodes which have lower delay. Suppose, if n_i receives duplicate RREQ request from its neighbor node n_j, it will check how many neighbors had been covered by RREQ of node n_j. Thus n_i could further adjust the UCN set according to neighbor list in the RREQ of the node n_j, i.e. $U(n_j)$, and is adjusted as follows:

$$U(n_i) = U(n_i) - [U(n_i) \cap N(n_j)] \qquad (3)$$

After adjusting $U(n_j)$, the RREQ packet received from node n_j is discarded.

When the timer of rebroadcast delay expires, the node n_i obtains final UCN set, which is used to calculate the *additional coverage ratio* $R_a(n_i)$ for node n_i:

$$R_a(n_i) = \frac{|U(n_i)|}{|N(n_i)|} \qquad (4)$$

This metric indicate the number of nodes that are additionally covered by the node n_i. The higher value of R_a indicates that more nodes will be covered by this rebroadcast and hence more nodes should receive and process the RREQ packet. Thus, the value of rebroadcast probability will be higher. But, R_a does not consider the node density and the overall network connectivity.

Xue and Kumar [10] has derived that if each node connects to more than 5.1774logn of its nearest neighbors, then the probability of the network being connected is approaching 1 as n increases, where n is the number of nodes in the network. So, 5.1774logn can be used as the connectivity metric of the network. The *connectivity factor* $F_c(n_i)$ for the node n_i is :

$$F_c(n_i) = \frac{N_c}{|N(n_i)|} \qquad (5)$$

Where N_c = 5.1774logn, and n is the number of nodes in the network.

Multiplying the additional coverage ratio and connectivity factor, we obtain *rebroadcast probability* $P(n_i)$ for node n_i:

$$P(n_i) = F_c(n_i) * R_a(n_i)$$

If $P(n_i)$ is greater than 1, then we set it to 1.

C. Algorithm of NCPR

Let $RREQ_s$ is the route request packet received from node s, Rs.id is unique identifier of $RREQ_s$,N(u) be the neighbor set of node u, U(u, x) is UCN set and Timer(u, x) is timer of node u for RREQ whose id is x.

During the actual implementation of NCPR, every node will receive different RREQ and on reception of RREQ, they will calculate their UCN set and set the timer.

1. If receives the $RREQ_s$ for the first time from s then
2. Find the initial UCN set U(s, Rs.id) for $RREQ_s$
3. Calculate rebroadcast delay $T(n_i)$
4. According to delay $T(n_i)$, set the Timer (n_i, Rs.id)
5. End if
6. While n_i receives duplicate $RREQ_j$ from before Timer(n_i, Rs.id) expires do
7. Adjust UCN set U(S, Rs.id)
8. Discard $RREQ_j$
9. End while
10. When timer is expires, we get the final UCN set
11. Calculate additional coverage ratio $R_a(n_i)$
12. Calculate connectivity factor $F_c(n_i)$
13. Compute Rebroadcast probability $P(n_i)$
14. Check if (Random(0,1) <= $P(n_i)$)
15. Broadcast $RREQ_s$
16. Else
17. Discard $RREQ_s$
18. End if

III. Protocol Implementation And Simulation Result

A. Protocol Implementation

The NCPR protocol is implement NS-2.34 using AODV as base protocol. The NCPR uses *Hello* protocol to get neighborhood information and then carry the neighbor list along with RREQ packet. To reduce overhead the *Hello* packet do not use periodical *Hello* mechanism but checks if the last broadcasting time of control packets is greater than *HelloInterval*, the node will send the *Hello* packet. The control packets such as RREQ and route error (RERR) can also act as *Hello* packet.

An additional field *nb_count* is added to the RREQ packet header to maintain the count of neighbor in the received RREQ packet. Since the node are mobile so there are three possibilities:

- Node n_i may receive duplicate RREQ packet (checked by comparing *sequence number* of RREQs) or new RREQ packet may be received so that node is to be added to neighbor list
- Some node may move out of coverage area of node n_i so that node is removed from neighbor list
- No node is added or removed from the neighbor list of node n_i.

The *nb_count* is set with a positive integer when the node is added and its value is equal to the number of new node added to neighbor list. Similarly when node are removed, *nb_count* is a negative integer and is equal to number of nodes deleted neighbors but if no node is added or removed is *nb_count* is set zero. Thus according to the value of *nb_count* the node updates the neighbor cache of node n_i.

B. Simulation Environment

The performance of the protocols is evaluated using following parameters:

a. *Average End-to-end delay*: The average delay experienced by constant bit rate (CBR) packets to reach from source to destination successfully.

b. *Packet Delivery Ratio*: It is the ratio of total number of packets reaching the destination to the total packet sent by the source.

c. *Normalized Routing Overhead*: It is the ratio of total packet size of control packets to the total packet size of data packets delivered to destination.

The performance of three protocols AODV, Load Balancing Single Path Routing (LBR) and NCPR is compared in this paper. LBR and NCPR are the protocols modified using the source code of AODV. For the simulation, we have considered CBR data traffic and the selection of source-destination is done randomly. The simulation field will be 1000 m × 1000m and transmission range of every node is 250. Every source will send four CBR packets whose size is 512 byte/sec in the multi-hop fashion. The net performance is evaluated by varying the number of nodes and the mobility of the nodes. The *MaxDelay* for rebroadcast delay is set to 0.01 sec.

The simulation parameter and scenarios for evaluating performance of protocols is given in the table below.

TABLE I. SIMULATION PARAMETERS

Simulator	NS 2.34
MAC Type	802.11
Channel Type	Wireless Channel
Transmission Range	250 m
Traffic	CBR
Routing Protocol	AODV, LBR NCPR
Antenna Model	Omni
Number of Nodes	5, 10, 20, 50, 100
Simulation Area	1000 m × 1000 m
Traffic Type	CBR / TCP
Data Payload	512 Bytes/Packet
Network Loads	4 Packet/Sec
Simulation Time	100 sec
Mobility	0, 5, 10, 25, 50 m/s
Connection	1,3,5,10
Interface Queue length	5, 10, 20, 50, 100

C. Simulation Result

1) Performance in Static Environment

Static environment is scenario in which mobility of the nodes of zero, i.e. the node are static.

The performance of the protocol is analyzed for the traffic load between the nodes is varied as 1, 3, 5 and 10 connection. For each connection, the interface queue length (ifqlen) by varied as 5, 10, 20, 50 and 100. And for each queue length, we find the value by for 10, 20, 50 and 100 nodes.

The Fig.1, Fig.2 and Fig.3 below shows the normalized routing overhead, packet delivery ratio and end-to-end respectively for ifqlen = 5 and connection = 3.

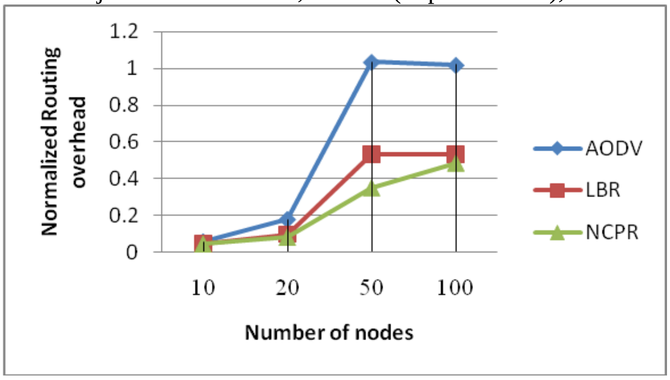

Fig. 1. **Normalized Routing Overhead Vs Number of Nodes (nodes are static)**

Fig 1 shows the graph of normalized routing overhead against the number of nodes; it can be seen that NCPR has lowest overhead among all.

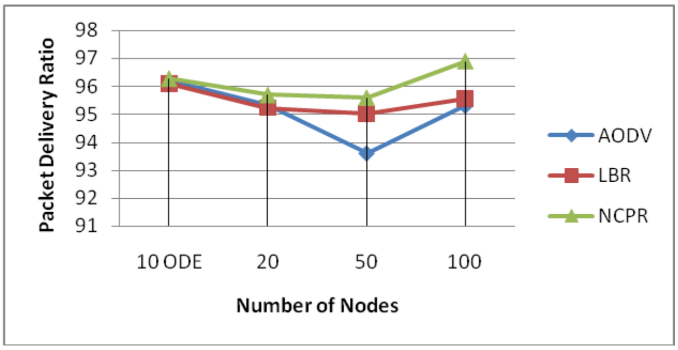

Fig. 2. **Packet Delivery Ratio Vs Number of Nodes(nodes are static)**

Fig 2 shows the graph of packet delivery ratio against the number of nodes; as the number of node increases, the packet delivery ratio highest in NCPR, lower in LBR and least in case of AODV.

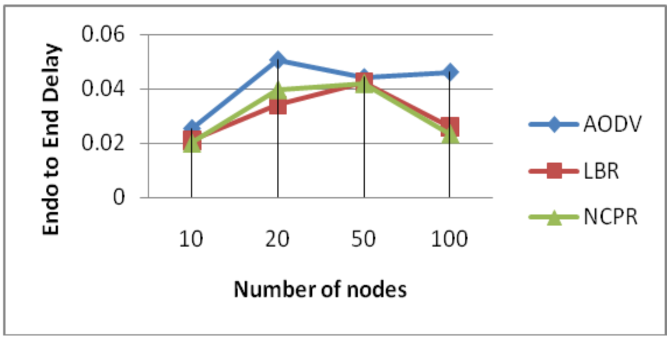

Fig. 3. **End to End Delay Vs Number of Nodes (nodes are static)**

Fig 3 shows the graph of end to end against the number of nodes; as the NCPR has smaller delay as the rebroadcast of RREQs is limited unlike AODV. Though LBR has delay close to the delay of NCPR.

2) Performance in Dynamic Environment

Unlike static, in dynamic environment the nodes are mobile. The nodes have mobility of 5, 10, 25 and 50 m/sec. The simulation scenarios for dynamic environment are similar to the static environment.

The below figure represent the normalized routing overhead, packet delivery ratio and end-to-end delay of the network in dynamic environment where ifqlen = 20 and connection = 3 and the mobility of nodes is 10 m/sec:

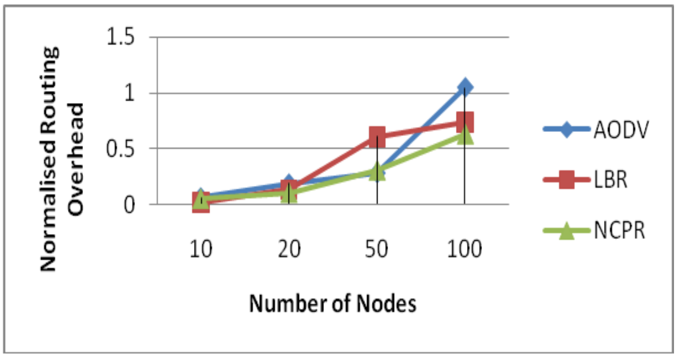

Fig. 4. **Normalized Routing Overhead Vs Number of Nodes(nodes are dynamic)**

Fig 4 shows the graph of normalized routing overhead against the number of nodes; as the node are mobile the overhead will increase as the number of node increases but in comparison to AODV and LBR, NCPR has the lowest overhead due to reduced number of controls packets unlike conventional which suffers from broadcast storm problem.

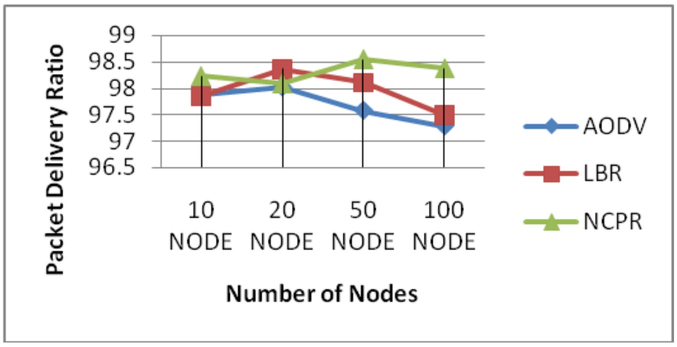

Fig. 5. **Packet Delivery Ratio Vs Number of Nodes(nodes are dynamic)**

Fig 5 shows the graph of packet delivery ratio against the number of nodes; LBR performs well for the lower number of node but as the number of nodes increases, the merits of NCPR are quiet visible from the graph.

Fig 6 which shows the graph of end to end against the number of nodes also shows the same observation as in the static environment and in the case also the end to end is lowest in the NCPR compared to conventional AODV.

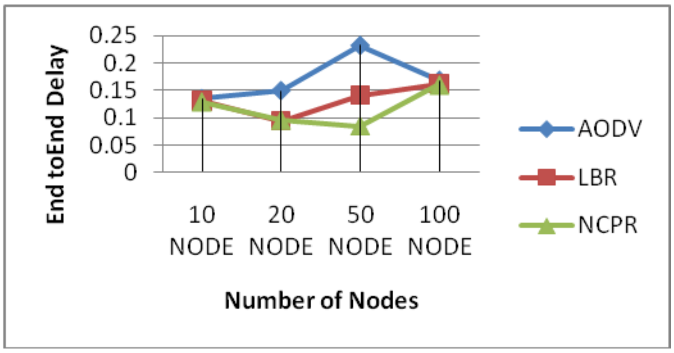

Fig. 6. **End to End Vs Number of Nodes(nodes are dynamic)**

IV. Conclusion

The conventional on-demand routing protocol suffers from broadcasting storm problem. So to overcome this problem, we propose NCPR protocol which combines the merits of neighbor coverage knowledge and probabilistic method. The NCPR will first calculate the rebroadcast delay to determine the forwarding order and then we calculate the rebroadcast probability. Thus the overhead in the network has also reduced which the additional coverage ratio and connectivity factor. The simulation result shows the proposed system reduces the end-to-end delay effectively since we have limited the rebroadcast of RREQs to only those nodes who receives RREQ it for the first time will eventually increase the packet delivery ratio. The simulation result also shows that since the control packets are reduced, the NCPR has good performance as the number of node increase.

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