



Dynamic Routing With Condensed Routing Overhead and Renew Cast of MANET

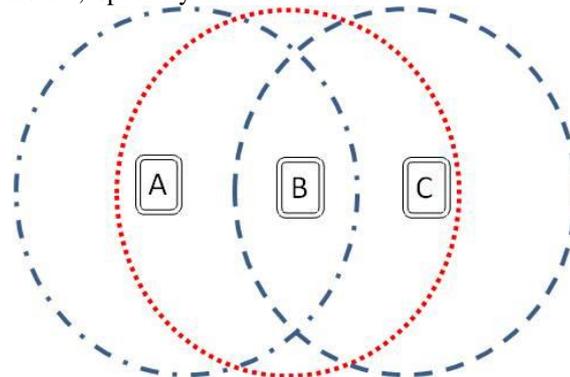
Megha Sharma*, Geetanjali Tyagi, Chandra Sekhar Tyagi
Computer Science & SRM University, U.P., India
Assit. Professor CSE Dept & SRM University, U.P., India

Abstract- ADHOC network refers to a network connection established for a single session and does not require a router or a wireless base station. The mobile nodes will not stay in a same position, frequent link breakages will occur which will lead to path failure and route discovery problems. In route discovery new cast is a fundamental and effective data promulgation mechanism, where a mobile nodes blindly new cast the first received route request packets unless it has route to the destination and thus it causes the new cast storm problem. In this paper we propose a dynamic routing with condensed routing overhead & renew cast of MANET. We propose a novel renew cast delay to determine the renew cast order, and then we can obtain the more accurate additional coverage ratio by sensing neighbour coverage knowledge. By combining the additional coverage ratio and connectivity factor, we set a reasonable renew cast probability which can significantly decrease the number of renew cast so as to reduce the routing overhead and can also improve the routing performance.

Keywords—mobile adhoc network, neighbour coverage, network connectivity, probabilistic, renew cast, routing overhead

I. INTRODUCTION

A manet is a type of adhoc network that can change locations and configure itself on the fly. One of the fundamental challenges of manet is the design of concentrated routing protocol with good performance. Many routing protocols, such as adhoc on-demand distance vector routing (AODV) and dynamic source routing (DSR), they could improve the scalability of manet by limiting the routing overhead when a new route is requested. However, due to node mobility in manets, frequent link breakages may lead to frequent path failures and route discoveries, which could increase the overhead of routing protocols and reduce the packet delivery ratio and increasing the end to end delay. Thus, reducing the routing overhead in route discovery is an essential problem. The conventional on demand routing protocols use flooding to discover a route. They broadcast a route request (RREQ) packet to the networks, and the broadcasting induces excessive redundant retransmission of RREQ packet and causes the broadcast storm problem [5], which lead to considerable number of packet collision, especially in dense network.



Fig(1) manet network

II. THE MAIN ANNOUNCEMENT OF THIS PAPER AS

1. We propose a novel scheme to calculate the rebroadcast delay. The rebroadcast delay is to determine the forwarding order. The node which has more common neighbors with the previous node has the lower delay. If this node rebroadcast delay enables the information that the nodes have transmitted the packet spread to more neighbors.
2. We also propose a novel scheme to calculate the rebroadcast probability. The scheme considers the information about the uncovered neighbors (UCN), connectivity metric and local node density to calculate the rebroadcast probability is composed of two parts:
 - a) additional coverage ratio, which is the ratio of the number of nodes that should be covered by a single

broadcast to the total number of neighbors

b) connectivity factor which reflects the relationship of network connectivity and the number of neighbor of a given node.

2.2. Study the paper scope

Since limiting the number of rebroadcast can effectively optimize the broadcasting and the neighbor knowledge methods perform better than the area-based ones and the probability based ones then we propose a neighbor coverage based probability (NCPR).

2.2.1. Additional coverage ratio

In order to effectively exploit the neighbor coverage knowledge, we need a novel rebroadcast delay to determine the rebroadcast order and then we can obtain a more precise additional coverage ratio.

2.2.2. Connectivity factor

In order to keep the network connectivity and reduce the redundant retransmissions, we need a metric named connectivity factor to determine how many neighbors should receive the RREQ packet

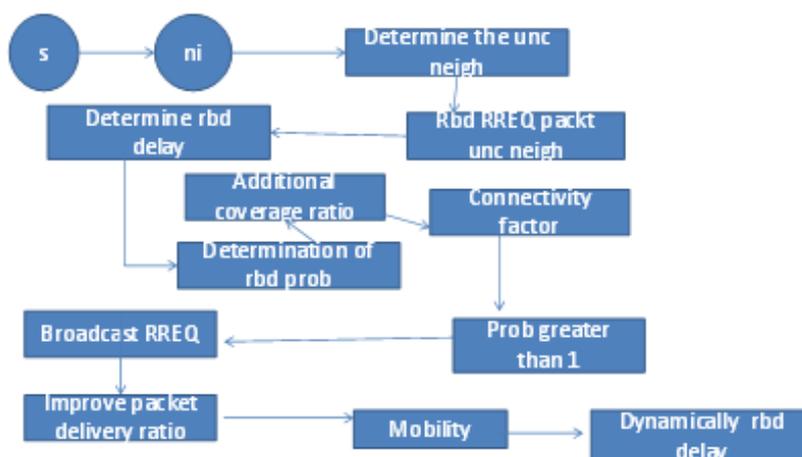
III. LITERATURE REVIEW

Broadcasting is an effective mechanism for route discovery, But the routing overhead associated with the broadcasting Can be quite large, especially in high dynamic networks [9]. Ni et al. [5] studied the broadcasting protocol analytically And experimentally, and showed that the rebroadcast is Very costly and consumes too much network resource. The Broadcasting incurs large routing overhead and causes many problems such as redundant retransmissions, contentions, and collisions [5]. Thus, optimizing the broadcasting In route discovery is an effective solution to improve The routing performance. Haas et al. [10] proposed a gossip based approach, where each node forwards a packet with a Probability. They showed that gossip-based approach can save up to 35 percent overhead compared to the flooding. However, when the network density is high or the traffic load is heavy, the improvement of the gossip-based approach is limited [9]. Kim et al. [8] proposed a probabilistic broadcasting scheme based on coverage area and neighbor confirmation. This scheme uses the coverage. Area to set the rebroadcast probability, and uses the neighbor confirmation to guarantee reach ability. Peng and Lu [11] proposed a neighbor knowledge scheme named Scalable Broadcast Algorithm (SBA). This scheme determines the rebroadcast of a packet according to the fact whether this rebroadcast would reach additional nodes.

Ab dulai et al. [12] proposed a Dynamic Probabilistic Route Discovery (DPR) scheme based on neighbor coverage. In This approach, each node determines the forwarding Probability according to the number of its neighbors and the set of neighbors which are covered by the previous Broadcast. This scheme only considers the coverage ratio by the previous node, and it does not consider the neighbours receiving the duplicate RREQ packet. Thus, there is a room of further optimization and extension for the DPR protocol. Several robust protocols have been proposed in recent years besides the above optimization issues for broadcasting. Chen et al. [13] proposed an AODV protocol with Directional Forward Routing (AODV-DFR) which takes the Directional forwarding used in geographic routing into AODV protocol. While a route breaks, this protocol can Automatically find the next-hop node for packet forwarding.

Keshavarz-Haddad et al. [14] proposed two deterministic Timer-based broadcast schemes: Dynamic Reflector Broadcast (DRB) and Dynamic Connector-Connector Broadcast (DCCB). They pointed out that their schemes can achieve full reach ability over an idealistic lossless MAC layer, and for the situation of node failure and mobility, their schemes are robustness. Stann et al. [15] proposed a Robust Broadcast Propagation (RBP) protocol to provide near-perfect reliability for flooding in wireless networks, and this protocol also has a good efficiency. They presented a new perspective for broadcasting: not to make a single broadcast more efficient but to make a single broadcast more reliable, which means by reducing the frequency of upper layer invoking flooding to improve the overall performance of flooding. In our protocol, we also set a deterministic rebroadcast delay, but the goal is to make the dissemination of neighbor knowledge much quicker.

BLOCK DIAGRAM



Fig(2) block diagram of dynamic routing

Analysis of problem

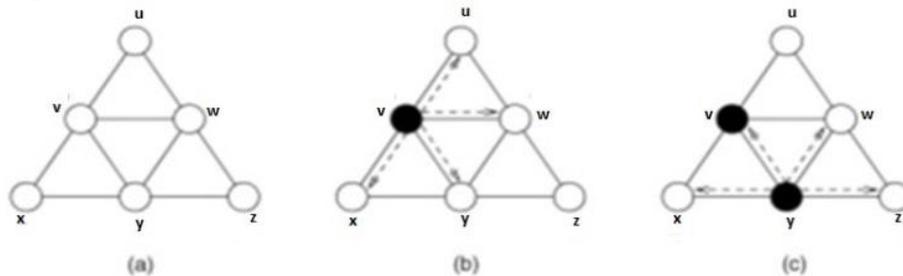
In mobile adhoc network nodes are moving continuously due to node mobility in manet frequent link breakages may lead to frequent path failures and route. They broadcast a route request (RREQ) packet to the network and the broadcasting induces excessive redundant retransmission of (RREQ) packet and causes the broadcast storm problem [5], which leads to a considerable number of packet collisions, especially in dense networks.

The broadcast storm problem:

A forwarding order approach to perform broadcast is by flooding .a host, on receiving a broadcast packet for the first time, has the obligation to rebroadcast the packet. Since, this costs n transmission in a Manet of n hosts.

- 1) **Redundancy:** when a mobile host broadcasts a packet if many of its neighbors decide to rebroadcast a broadcast packet to its neighbor, all of its neighbor might already have heard the packet.
- 2) **Contention:** After a mobile host broadcasts a packet if many of its neighbor decide to rebroadcast the packet, these transmission may severely contend with each other.

In flooding, a broadcast packet is forwarded by every node in the network exactly once. The broadcast packet is absolutely to be received by every node in the network providing there is no packet loss caused be collision in the MAC layer and there is no high speed movement of nodes during the broadcast process. Figure show a network w th six nodes .when node v broadcast a packet all neighboring nodes .u, w, x and y receive the packet due to the broadcast nature of wireless communication media. All neighbors will then forward the packet to each other. Apparently, the two transmissions from nodes u and x are unnecessary. Redundant transmissions may cause the broadcast storm problem [18] in which redundant packets cause contention and collision.



Fig(3) show the storm problem

IV. PROPOSED WORK

To calculate the rebroadcast delay and rebroadcast probability of the proposed protocol . using the upstream coverage ratio of an RREQ packet received from the previous node to calculate the rebroadcast delay and use the additional coverage ratio of the RREQ packet and the connectivity factor to calculate rebroadcast probability in our protocol, which requires that each node needs its 1- hop neighborhood information.

Uncovered neighbor set and rebroadcast delay

the node receives the RREQ packet from its earlier node s, to use the neighbor list in the RREQ packet to estimate how many its neighbors have been not covered by the RREQ packet from s. the node ni has more neighbor not covered by the RREQ packet from the source and the RREQ packet form can reach more additional neighbor nodes when node ni rebroadcast the RREQ packet . To quantify of the uncovered neighbor (UCN) set u (ni) of node.

$$U (ni) =N (ni)-[N (ni) \cap N(s)]-\{s\} \tag{1}$$

The rebroadcast delay Td (Ni) of node Ni.

$$Tp (ni) =1-|N(s) \cap N(ni)|/|N(s)| \tag{2}$$

$$Td(Ni) = \max \text{ delay } *Tp(ni)$$

Neighbor knowledge and rebroadcast probability

The node which has a larger rebroadcast delay may listen to RREQ packets from the nodes which have lower one. For example if node ni receives a duplicate RREQ packet from its neighbor nj , it knows that how many its neighbors have been covered by the RREQ packet from nj. thus node ni could further adjust its UCN set according to the neighbor list in the RREQ packet from nj.

$$U(Ni) = u(ni)-[u(ni) \cap n(nj)] \tag{3}$$

Now we study how to use the final UCN set to set the rebroadcast probability.

$$Ra (ni) =|U(ni)|/|N(ni)| \tag{4}$$

$$Fc (ni) =Nc/|N(ni)| \tag{5}$$

$Nc=5.1774 \log n$, the n is the number of nodes in the network $|N(ni)| >Nc,fc(ni)<1$ in the dense area of the network . $|N(ni)| <Nc, fc(ni)>1$ in the sparse area of the network, then node ni should forward the RREQ packet in order to pproach network connectivity .combining the additional coverage ratio and connectivity factor, to obtain the rebroadcast probability pre(ni) of node ni :

$$Pre(ni)=f c(ni).ra(ni) \tag{6}$$

Where , if the pre(ni) is >1 , to set the pre (ni) to 1.

Algorithm description:

The formal description of the Neighbor Coverage-based Probabilistic Rebroadcast for reducing routing overhead in route discovery is shown in Algorithm 1.

Algorithm 1. NCPR

Definitions:

RREQ v: RREQ packet received from node v.

Rv.id: the unique identifier (id) of RREQ v.

N(u): Neighbor set of node u.

U(u, x): Uncovered neighbors set of node u for RREQ whose id is x.

Timer(u, x): Timer of node u for RREQ packet whose id is x.

{Note that, in the actual implementation of NCPR protocol, every different RREQ needs a UCN set and a Timer.}

1: if n_i receives a new RREQs from s then

2: {Compute initial uncovered neighbors set $U(n_i, R_s, id)$ for RREQ s:}

3: $U(n_i, R_s, id) = N(n_i) - [N(n_i) \setminus N(s)] - (s)$

4: {Compute the rebroadcast delay $T_d(n_i)$:}

5: $T_p(n_i) = 1 - |N(s) \cap N(n_i)| / |N(s)|$

6: $T_d(n_i) = \text{max delay} * T_p(n_i)$

7: Set a $\text{Timer}(n_i, R_s, id)$ according to $T_d(n_i)$

8: end if

9:

10: while n_i receives a duplicate RREQ j from n_j before $\text{Timer}(n_i, R_s, id)$ expires do

11: {Adjust $U(n_i, R_s, id)$:}

12: $U(n_i, R_s, id) = U(n_i, R_s, id) - [U(n_i, R_s, id) \setminus N(n_j)]$

13: discard(RREQ j)

14: end while

15:

16: if $\text{Timer}(n_i, R_s, id)$ expires then

17: {Compute the rebroadcast probability $\text{Pre}(n_i)$:}

18: $R_a(n_i) = |U(n_i, R_s, id)| / |N(n_i)|$

19: $F_c(n_i) = N_c / |N(n_i)|$

20: $\text{Pre}(n_i) = f_c(n_i) * R_a(n_i)$

21: if $\text{Random}(0, 1) \leq \text{Pre}(n_i)$ then

22: broadcast (RREQs)

23: else

24: discard (RREQs)

25: end if

26: end if

Random way point algorithm:

Step 1: select a random destination (within the specified network)

Step 2: select a random speed ($0 < v \leq \text{max_speed}$)

Step 3: move

Step 4: after reaching the destination

Step 5: pause a random time ($0 < p < \text{max_pause_time}$)

V. PROTOCOL IMPLEMENTATION AND PERFORMANCE EVALUATION

5.1 Protocol Implementation

We modify the source code of AODV in OPNET17.5 to implement our proposed protocol. Note that the proposed NCPR protocol needs Hello packets to obtain the neighbour information, and also needs to carry the neighbor list in the RREQ packet. Therefore, in our implementation, some techniques are used to reduce the overhead of Hello packets and neighbor list in the RREQ packet, which are described as follows:

. In order to reduce the overhead of Hello packets, we do not use periodical Hello mechanism. Since a node sending any new cast packets can inform its neighbors of its existence, the broadcasting packets such as RREQ and route error (RERR) can play a role of Hello packets. We use the following mechanism [17] to reduce the overhead of Hello packets: Only when the time elapsed from the last broadcasting packet (RREQ, RERR, or some other broadcasting packets) is greater than the value of Hello Interval, the node needs to send a Hello packet. The value of Hello Interval is equal to that of the original AODV.

. In order to reduce the overhead of neighbor list in the RREQ packet, each node needs to monitor the variation of its neighbor table and maintain a cache of the neighbor list in the received RREQ packet. We modify the RREQ header of AODV, and add a

fixed field num_neighbors which represents the size of neighbor list in the RREQ packet and following the num_neighbors is the dynamic neighbor list. In the interval of two close followed sending or forwarding of RREQ packets, the neighbor table of any node ni has the following three cases:

- if the neighbor table of node ni adds at least one new neighbor nj, then node ni sets the num_ neighbors to a positive integer, which is the number of listed neighbors, and then fills its complete neighbor list after the num_neighbors field in the RREQ packet. It is because that node nj may not have cached the neighbor information of node ni, and, thus, node nj needs the complete neighbor list of node ni;
- if the neighbor table of node ni deletes some neighbors, then node ni sets the num_neighbors to a negative integer, which is the opposite number of the number of deleted neighbors, and then only needs to fill the deleted neighbors after the num_neighbors field in the RREQ packet;
- if the neighbor table of node ni does not vary, node ni does not need to list its neighbors, and set the num_neighbors to 0. The nodes which receive the RREQ packet from node ni can take their actions according to the value of num_neighbors in the received RREQ packet:
 - if the num_neighbors is a positive integer, the node substitutes its neighbor cache of node ni according to the neighbor list in the received RREQ packet;
 - if the num_neighbors is a negative integer, the node updates its neighbor cache of node ni and deletes the deleted neighbors in the received RREQ packet;
 - if the num_neighbors is 0, the node does nothing. Because of the two cases 2 and 3, this technique can reduce the overhead of neighbor list listed in the RREQ packet.

5.2 Simulation Environment

In order to evaluate the performance of the proposed NCPR protocol, we compare it with some other protocols using the OPNET 17.5. new cast is a fundamental and effective data concentrated mechanism for many applications in MANETs. In this paper, we just study one of the applications: route request in route discovery. In order to compare the routing performance of the proposed NCPR protocol, we choose the Dynamic Probabilistic Route Discovery [12] protocol which is an optimization scheme for reducing the overhead of RREQ packet incurred in route discovery in the recent literature, and the conventional AODV protocol. Simulation parameters are as follows: The Distributed Coordination Function (DCF) of the IEEE802.11 protocol is used as the MAC layer protocol. The radio channel model follows a Lucent's Wave LAN with a bit rate of 2 Mbps, and the transmission range is 250 meters. We consider constant bit rate (CBR) data traffic and randomly choose different source-destination connections. Every source sends four CBR packets whose size is 512 bytes per second. The mobility model is based on the random waypoint model in a field of 1km_1km. In this mobility model, each node moves to a random selected destination with a random speed from a uniform distribution [1, max-speed]. After the node reaches its destination, it stops for a pause time interval and chooses a new destination and speed. In order to reflect the network mobility, we set the max-speed to 5 m/s and set the pause time to 0. The Max Delay used to determine the rebroadcast delay is set to 0.01 s, which is equal to the upper limit of the random jitter time of sending broadcast packets in the default implementation of AODV in opnet 17.5. Thus, it could not induce extra delay in the route discovery. The simulation time for each simulation scenario is set to 300 seconds. In the results, each data point represents the average of 30 trials of experiments. The confidence level is 95 percent, and the confidence interval is shown as a vertical bar in the figures.

The detailed simulation parameters are shown in Table 1.

Simulation parameter	value
Topology size	1km*1 km
Number of nodes	20,30,50.....300
Transmission range	260 m
Band width	3mbps
Interface queue length	50
Traffic type	CBR
Number of CBR connections	10,12,14.....20
Packet size	512 bytes
Packet rate	4 packet/sec
Pause time	0s
Min speed	1 m/s
Max speed	5 m/s

We evaluate the performance of routing protocols using the following performance metrics:

. **MAC collision rate:** the average number the average number of packets (including RREQ, route reply (RREP), RERR, and CBR data packets) dropped resulting from the collisions at the MAC layer per second. Normalized routing overhead: the ratio of the total packet size of control packets (include RREQ, RREP, RERR, and Hello) to the total packet size of data packets delivered to the destinations. For the control packets sent over multiple hops, each single hop is counted as

one transmission. To preserve fairness, we use the size of RREQ packets instead of the number of RREQ packets, because the DPR and NCPR protocols include a neighbor list in the RREQ packet and its size is bigger than that of the original AODV.

. **Packet delivery ratio:** the ratio of the number of data packets successfully received by the CBR destinations to the number of data packets generated by the CBR sources.

. **Average end-to-end delay:** the average delay of successfully delivered CBR packets from source to destination node. It includes all possible delays from the CBR sources to destinations. The experiments are divided to three parts, and in each part we evaluate the impact of one of the following parameters on the performance of routing protocols:

. **Number of nodes** . We vary the number of nodes from 20 to 300 in a fixed field to evaluate the impact of different network density. In this part, we set the number of CBR connections to 15, and do not introduce extra packet loss.

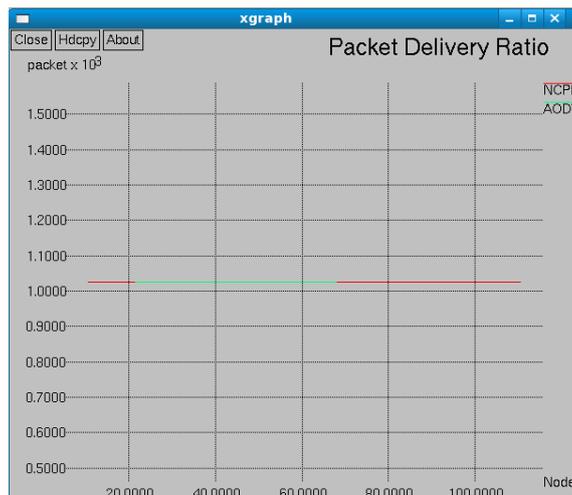
. **Number of CBR connections.** We vary the number of randomly chosen CBR connections from 10 to 20 with a fixed packet rate to evaluate the impact of different traffic load. In this part, we set the number of nodes to 150, and also do not introduce extra packet loss.

. **Random packet loss rate.** We use the Error Model provided in the opnet 17.5 to introduce packet loss to evaluate the impact of random packet loss. The packet loss rate is uniformly distributed, whose range is from 0 to 0.1. In this part, we set the number of nodes to 100 and set the number of connections to 15. In the experiments analysis, when two protocols are compared, we use the following method to calculate the average: we assume that the varied parameter is (x1; x2; . . . ; xn), the performance metric of protocol 1 is (y1; y2; . . . ; yn) and the performance metric of protocol 2 is (z1; z2; . . . ; zn).

When protocol 1 compares to protocol 2, the average is defined as: $[(y1 - z1)/z1 + (y2 - z2)/z2 + \dots + (yn - zn)/zn]/n * 100\%$.

VI. PERFORMANCE EVALUATION

This result will show the comparison of AODV and NCPR using the term packet delivery, end to end delay, mac collision rate, normalized routing overhead. Packet delivery ratio comparison between AODV and NCPR protocol. The packet delivery ratio means plot the graph between node and average packet delivery. It shows that PDR of AODV is efficient.



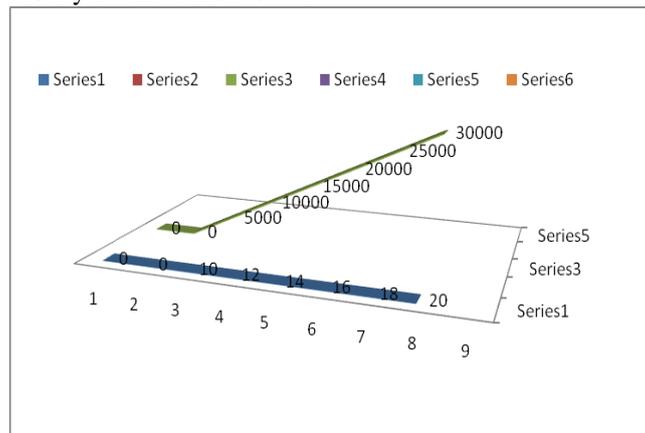
Fig(5) this figure show packet delivery ratio

The end to end delay of NCPR is high at initial time interval but when time increases as compared to AODV. In average packet delay of NCPR protocol is more efficient than ADV protocol packet delay.



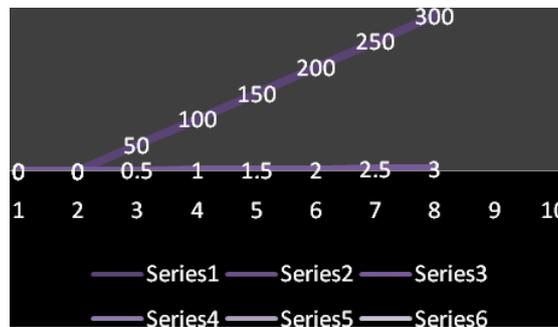
Fig(6) this figure show end-to end delay

shows the effects of the traffic load on the MAC collision rate. Since the data and control packets share the same physical channel in the IEEE 802.11 protocol, as the number of CBR connections increases, the physical channel will be busier and then the collision of the MAC layer will be more severe



Fig(7) this figure show the mac collision

shows the effects of the packet loss rate on the MAC collision rate. In our simulation parameters, we use both the IncomingErrProc and OutgoingErrProc options at the same time; thus, the packet error will be more often and the retransmissions caused by random packet loss at MAC layer will be more. Therefore, the MAC collision rate of all the three routing protocols increases as the packet loss rate increases.



Fig(8) this figure show the normalized routing overhead

VII. CONCLUSION

In this paper introduced dynamic routing with condensed routing overhead and renew cast of manet.the Paper to be constructed on the basis of good performance of the network is in high density or the traffic load is high. We proposed a new scheme to dynamically calculate the rebroadcast delay, which is used to determine the forwarding order and more exploit the neighbour coverage knowledge and random way poi nt . Because of less redundant renewcast the proposed protocol mitigates the network collision and contention, so as to increase the packet delivery ratio and decrease the average end to end delay it will also normalized the routing overhead.



Fig(9) this figure will show the manet network

Abbreviated terms for block diagram:

- S represent: source node
- N_i represent: i th node
- Unc neigh represent : uncovered neighbor
- Rbd represent : rebroadcast
- Prob represent: probability

REFERENCES

- [1] C. Perkins, E. Belding-Royer, and S. Das, Ad Hoc On-Demand Distance Vector (AODV) Routing, IETF RFC 3561, 2003.
- [2] D. Johnson, Y. Hu, and D. Maltz, The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks (DSR) for IPv4, IETF RFC 4728, vol. 15, pp. 153-181, 2007.
- [3] H. AlAamri, M. Abolhasan, and T. Wysocki, "On Optimising Route Discovery in Absence of Previous Route Information in MANETs," Proc. IEEE Vehicular Technology Conf. (VTC), pp. 1-5, 2009.
- [4] X. Wu, H.R. Sadjadpour, and J.J. Garcia-Luna-Aceves, "Routing Overhead as a Function of Node Mobility: Modeling Framework and Implications on Proactive Routing," Proc. IEEE Int'l Conf. Mobile Ad Hoc and Sensor Systems (MASS '07), pp. 1- 9, 2007.
- [5] S.Y. Ni, Y.C. Tseng, Y.S. Chen, and J.P. Sheu, "The Broadcast Storm Problem in a Mobile Ad Hoc Network," Proc. ACM/IEEE MobiCom, pp. 151-162, 1999.
- [6] A. Mohammed, M. Ould-Khaoua, L.M. Mackenzie, C. Perkins, and J.D. Abdulai, "Probabilistic Counter-Based Route Discovery for Mobile Ad Hoc Networks," Proc. Int'l Conf. Wireless Comm. And Mobile Computing: Connecting the World Wirelessly (IWCMC '09), pp. 1335-1339, 2009.
- [7] B. Williams and T. Camp, "Comparison of Broadcasting Techniques for Mobile Ad Hoc Networks," Proc. ACM MobiHoc, pp. 194- 205, 2002
- [8] J. Kim, Q. Zhang, and D.P. Agrawal, "Probabilistic Broadcasting Based on Coverage Area and Neighbor Confirmation in Mobile Ad Hoc Networks," Proc. IEEE GlobeCom, 2004.
- [9] J.D. Abdulai, M. Ould-Khaoua, and L.M. Mackenzie, "Improving Probabilistic Route Discovery in Mobile Ad Hoc Networks," Proc. IEEE Conf. Local Computer Networks, pp. 739-746, 2007.
- [10] Z. Haas, J.Y. Halpern, and L. Li, "Gossip-Based Ad Hoc Routing," Proc. IEEE INFOCOM, vol. 21, pp. 1707-1716, 2002.
- [11] W. Peng and X. Lu, "On the Reduction of Broadcast Redundancy in Mobile Ad Hoc Networks," Proc. ACM MobiHoc, pp. 129-130, 2000.
- [12] J.D. Abdulai, M. Ould-Khaoua, L.M. Mackenzie, and A. Mohammed, "Neighbour Coverage: A Dynamic Probabilistic Route Discovery for Mobile Ad Hoc Networks," Proc. Int'l Symp. Performance Evaluation of Computer and Telecomm. Systems (SPECTS'08), pp. 165-172, 2008.
- [13] J. Chen, Y.Z. Lee, H. Zhou, M. Gerla, and Y. Shu, "Robust Ad Hoc Routing for Lossy Wireless Environment," Proc. IEEE Conf. Military Comm. (MILCOM '06), pp. 1-7, 2006.
- [14] A. Keshavarz-Haddady, V. Ribeiro, and R. Riedi, "DRB and DCCB: Efficient and Robust Dynamic Broadcast for Ad Hoc and Sensor Networks," Proc. IEEE Comm. Soc. Conf. Sensor, Mesh, and Ad Hoc Comm. and Networks (SECON '07), pp. 253-262, 2007
- [15] F. Stann, J. Heidemann, R. Shroff, and M.Z. Murtaza, "RBP: Robust Broadcast Propagation in Wireless Networks," Proc. Int'l Conf. Embedded Networked Sensor Systems (SenSys '06), pp. 85-98, 2006.
- [16] F. Xue and P.R. Kumar, "The Number of Neighbors Needed for Connectivity of Wireless Networks," Wireless Networks, vol. 10, no. 2, pp. 169-181, 2004.
- [17] X.M. Zhang, E.B. Wang, J.J. Xia, and D.K. Sung, "An Estimated Distance Based Routing Protocol for Mobile Ad Hoc Networks," IEEE Trans. Vehicular Technology, vol. 60, no. 7, pp. 3473-3484, Sept. 2011.