International Journal Of Scientific & Engineering Research, Volume 5, Issue 3, March-2014
ISSN 2229-5518

Routing Overhead Reduction in MANETs

V.Hema, M.Mohanapriya

Abstract—Routing is one of the challenging issues in Mobile Ad hoc NETworks (MANETs). Broadcasting is the fundamental and efficient data dissemination mechanism for route discovery in reactive routing protocols of Mobile Ad hoc NETwork (MANET). This causes the problem called the broadcast storm problem which results in redundant retransmission and adds to routing overhead. There are many approaches proposed to solve the problem; but none of them addresses the problem effectively. This paper proposes a new mechanism that has probabilistic rebroadcast based on neighbor coverage for the routing overhead reduction. This proposed mechanism will reduces the packet retransmission and thus reduce the routing overhead. This approach combines the advantages of probabilistic mechanism and neighbor area coverage based approach. This new mechanism can improve the performance of broadcasting in various network scenarios. This approach is simple and can be implemented in NS-2.

Keywords—Ad Hoc Network, broadcast storm, MANET, probabilistic rebroadcasting, AODV, RREQ, RERR.

———————————— ◆ ————————————

1 Introduction

Mobile Ad Hoc Networks (MANETs) consist of nodes that change position frequently. Each node in a mobile ad hoc network functions as both the host and the router, and also the control of the network is distributed among the nodes present. The network topology is dynamic since the connectivity among the nodes varies with time due to node departures, new node arrivals, and also due to movement of nodes. The re-active routing protocols (or on-demand protocols) [13, 6] starts a route discovery process when needed. When a route from the source to the destination is needed, route searching procedure is started. Due to increase in the movement of nodes in mobile ad hoc networks (MANETs), frequent link breakages occurs often which results in frequent path failures and needs route discoveries. The conventional reactive routing protocol [13, 6] uses flooding to find the routes between source and destination. It simply broadcast the route request packet when the path is needed. The process continues until it finds the route to the destination. This broadcasting induces the redundant retransmission. This further causes overhead in route discovery. Broadcasting is the basic and fundamental data dissemination mechanism, in which a mobile node rebroadcasts the route request packets until it has a route to the required destination, and this causes the broadcast storm problem [11]. This paper implements the new broadcasting technique to reduce the overhead of routing packets. This technique exploits the neighborhood knowledge using rebroadcast delay and also obtains the coverage ratio of a node. The connectivity factor and the coverage ratio is used to calculate the rebroadcast probability. The connectivity factor is used to determine the number of nodes that need to receive the Route Request packet. In order to reduce the overhead, the periodical Hello packets are not used. Since a node sending any broadcasting packets can inform its presence to its neighbors, the broadcasting packets such as Route REQuest (RREQ) and Route ERRor (RERR) can play a role of Hello packets.

The new proposed mechanism for reducing the routing overhead is given in the Section III. The algorithm used for reducing the routing overhead is given in the Section IV.

2 Literature Review

The routing overhead occurs because of the dissemination of routing control packets such as RREQ packets can be large, when the network topology changes frequently. The on-demand routing protocols [13, 6] produce a large amount of routing traffic by flooding the entire network with RREQ packets in route discovery process. The issue of reducing the routing overhead associated with route discovery and maintenance in on demand routing protocols has attracted the research work. Nelson et al [10] proposed a methodology of dynamically adjusting the Hello timer and the Timeout timer according to the conditions of the network. In a high mobility network with frequent topology changes the small values for the timers is used to quickly detect the changes in the network. In a low mobility

- *V.Hema is currently pursuing masters degree program in Computer Science and Engineering in Sri Krishna College of Engineering and Technology. E-mail: hemsinfotech22@gmail.com*
- *Ms.M.Mohanapriya is currently working as Assistant Professor in Computer Science and Engineering in Sri Krishna College of Engineering and Technology, Coimbatore.*

International Journal Of Scientific & Engineering Research, Volume 5, Issue 3, March-2014
ISSN 2229-5518

network where the topology remains stable or with the few changes, a large value of the timers is effective to reduce the overhead. The reduction of overhead is greatly achieved with the minimal cost of slightly increasing the drop rate in data traffic. If the packet loss increases by 1%, the overhead reduction reaches 40%. Ould-Khaoua [9] proposed the two new probabilistic route discovery method known as Adjusted Probabilistic route discovery process (AP) and Enhance Adjusted Probabilistic route discovery process (EAP) which solves the broadcast storm problem in the existing on-demand routing protocols. The probability for forwarding is determined by the local density of the sending node. To reduce the routing overhead without reducing the network throughput in dense network topology, the probability of packet forwarding by the nodes located in sparse areas is set high while it is set low at nodes located in dense areas. EAP-AODV reduces overhead by 71% while APAODV reduces the overhead by 55%.

Aminu [18] proposed a rebroadcast probability function which takes in to account about the value of the packet counter together with some key simulation parameters like size of network topology, transmission range and the number of nodes to determine the appropriate rebroadcast probability for a given node. The rebroadcast probability of the node is calculated based on the parameters. Compared to the other mechanisms, simulation results have revealed that counter Function achieved superior saved rebroadcast about 20% better than its closest competitor like counter-based scheme in the dense network and end to end delay around 26% better than counter-based scheme in dense network without sacrificing reach ability in medium and dense networks. Kim [8] proposed the probabilistic broadcasting method based on the coverage area and the neighbor confirmation. This method uses coverage area to set rebroadcast probability and it uses the neighbor confirmation to make the reachability. Haas [5] proposed the gossip approach in which each node forwards a packet with probability. This method can reduce to 35% overhead when compared to flooding. Peng and Lu [12] proposed a neighbor knowledge method named SBA- Scalable Broadcast Algorithm. This method determines the rebroadcast of packet, based on whether the rebroadcast can reach the additional nodes. Abdulai [2] proposed Dynamic Probabilistic Route Discovery (DPR) method based on neighbor coverage method. In this method, each node determines the probability for forwarding packets based on the number of its neighbors and also the set of neighbors which are covered by previous broadcast.

3 Probabilistic Rebroadcast With Neighbor Knowledge (PRNK) Mechanism

This paper proposes Probabilistic Rebroadcast with Neighbor Knowledge (PRNK) mechanism which combines both neighbor coverage and probabilistic methods. In order to determine the neighbor coverage knowledge, the rebroadcast delay is used to determine the rebroadcast order, and the accurate coverage ratio is obtained. To keep the network connectivity and to reduce the redundant retransmissions, connectivity factor is used to determine the number of neighbors to receive the RREQ packet [17]. The coverage ratio and the connectivity factor are combined finally. The upstream coverage ratio of an RREQ packet received from the previous node is used to calculate the rebroadcast delay and the coverage ratio of the RREQ packet and the connectivity factor is used to calculate the rebroadcast probability. The rebroadcast probability is found, to reduce the number of RREQ packet rebroadcasts and to improve the routing performance.

3.1 Rebroadcast Delay

This mechanism proposes a method to determine the rebroadcast delay. The rebroadcast delay is used to determine the forwarding order. The node that has more common neighbors with its previous node will have the lower delay. If the node rebroadcasts the packet its common neighbors will know this information. So, the rebroadcast delay used to spread the information about the nodes that have disseminated the packet to more neighbors. When a node n_i receives RREQ packet from its previous node ns, then node ns can uses the neighbor list in the RREQ packet to determine how many of its neighbors have not been covered by the RREQ packet. If node n_i has more neighbors that are not covered by the RREQ packet from ns, then if node n_i rebroadcasts the RREQ packet, the RREQ packet will reach more additional neighbor nodes. When node ns sends an RREQ packet, all of its neighbors n_i, where i = 1, 2… receive and process the RREQ packet. Assume the node n_k has the largest number of common neighbors with node ns, and then node n_k has the lowest delay. If the node n_k rebroadcasts the RREQ packet then there are more nodes to receive the RREQ because node n_k has the largest number of common neighbors. The node n_k rebroadcasts the RREQ packet depends on the rebroadcast probability. The purpose of the rebroadcast delay is not to rebroadcast the RREQ packet to more nodes but to spread the neighbor coverage knowledge more quickly. The node can set timer value after determining the rebroadcast delay.

International Journal Of Scientific & Engineering Research, Volume 5, Issue 3, March-2014
ISSN 2229-5518

3.2 Rebroadcast Probability

This paper also proposes the method to determine the rebroadcast probability. The method considers the uncovered neighbors and connectivity metric and also the local node density to determine the rebroadcast probability. The rebroadcast probability consists of two parts. The first part is the coverage ratio, which is the ratio of number of nodes covered by a single broadcast to the total number of neighbors and second part is the connectivity factor which shows the relationship of network connectivity and the number of neighbors of the given node. Node which has a larger rebroadcast delay will listen to RREQ packets from the nodes which have lower delay [3]. The rebroadcast delay is not adjusted because it is used to calculate the order of disseminating neighbor coverage information. When the timer value of the rebroadcast delay of node n_i expires the node gets the final uncovered neighbor set value. The nodes which belonging to the final uncovered neighbor set are the nodes that receive and process the RREQ packets. If the node is not able to find any duplicate RREQ packet from its neighbors, then its uncovered neighbor set is unchanged. The rebroadcast probability can be calculated as follows. The value Ra shows the ratio of the number of nodes that are additionally covered by this rebroadcast to the total number of neighbors of the node ni. The nodes that are additionally covered by the broadcast need to receive and process the RREQ packet. When the Ra becomes bigger, then more nodes will be covered by this rebroadcast so that more nodes need to receive and process the RREQ packet. This leads to set the rebroadcast probability value higher. Xue [17] showed each node that connects to more than 5.1774 log n of its nearest neighbor nodes then the probability of the network being connected is reaching 1 as the value of n increases. Here n is the number of nodes in the network. So the value 5.1774 log n can be used as the connectivity metric of the network. The ratio of the number of nodes needs to receive the RREQ packet to the total number of neighbors to the node n_i is $Fc(n_i)$. When the local node density is low, the value of Fc increases the rebroadcast probability and so increases the reliability of the PRNK in the sparse area. When the local node density is high, the value of Fc decreases the rebroadcast probability and so increases the effectiveness of PRNK in the dense area. The parameter Fc adds the density adaptation to the rebroadcast probability.

4 Algorithm

The algorithm is given to reduce the routing overhead in route discovery as follows:

RREQs: RREQ packet received from node s.
Rs. id: the unique identifier (id) of RREQs.
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.

ALGORITHM

if n_i receives new RREQs from s then
  Compute initial uncovered neighbors set U (ni, Rs.id) for RREQs:

$$U(n_i, Rs.id) = N(n_i) - [N(n_i) \cap N(s)] - \{s\}$$

  Compute the rebroadcast delay Td (n_i):

$$Tp(n_i) = 1 - \frac{|N(s) \cap N(n_i)|}{|N(s)|}$$

$$Td(n_i) = MaxDelay * Tp(n_i)$$

  Set a Timer (n_i, Rs: id) according to Td (n_i)
end if
while (n_i receive a duplicate $RREQ_j$ from n_j before Timer (n_i, Rs.id) expires) do
  Adjust U (n_i, Rs. id):

$$U(n_i, Rs{:}id) = U(n_i, Rs{:}id) - [U(n_i, Rs{:}id) \cap N(n_i)]$$

discard ($RREQ_j$)
end while
if Timer (n_i, Rs. id) expires then
  Compute the rebroadcast probability Pre (n_i)

$$Ra(ni) = \frac{|U(ni, Rs.id)|}{|N(ni)|}$$

$$Fc(ni) = \frac{Nc}{|N(ni)|}$$

$$Pre(n_i) = Fc(n_i) * Ra(n_i)$$

if Random (0, 1) $\leq$ Pre (n_i) then
  broadcast (RREQs)
else
  Discard (RREQs)
end if

5 Protocol Implementation

To implement the proposed mechanism the source code of AODV is enhanced in NS-2 [19, 20].

International Journal Of Scientific & Engineering Research, Volume 5, Issue 3, March-2014
ISSN 2229-5518

Figure 1 shows the data flow diagram for the proposed model.

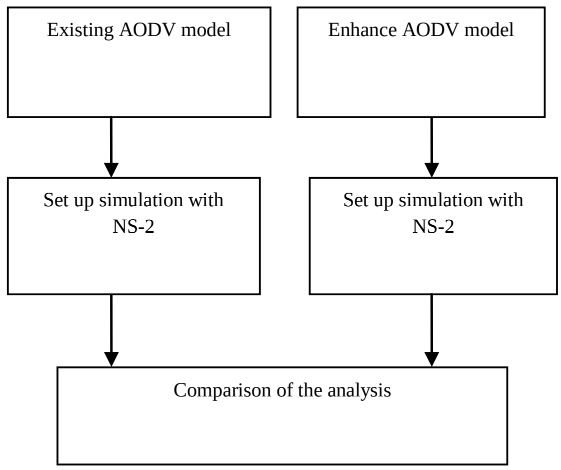

Fig.1. Data Flow Diagram

The proposed PRNK method needs Hello packets to get the neighbor details and needs to carry the neighbor list in RREQ packet. Therefore some methods are used to reduce the overhead of Hello packets. In order to reduce the overhead of Hello packets, the periodical Hello mechanism is not used. Because when a node sends the broadcasting packets, it can inform its existence to its neighbors. The broadcasting packets like Route REQuest (RREQ) and Route ERRor (RERR) play a role of Hello packets. Each and every node monitors the neighbor table and maintains the neighbor list in the received RREQ packet in order to reduce the overhead of neighbor list in RREQ packet. The neighbor table of any node n_i has the three cases to send or forward of RREQ packets:

1) The node n_i sets the number of neighbors to a positive integer if the neighbor table of node n_i adds one new neighbor n_j.

2) The node n_i sets the number of neighbors to a negative integer if the neighbor table of node n_i deletes any of its neighbors.

3) The node n_i does not need to list its neighbors if the neighbor table of node n_i does not vary and set the number of neighbors to 0.

The nodes when receives the RREQ packet from node n_i can take their actions according to the value of num neighbors in the received RREQ packet:-

i) If the number of neighbors is a positive integer then node substitutes its neighbor cache of node n_i according to the neighbor list in the received RREQ packet.

ii) If the number of neighbors is a negative integer then node updates its neighbor cache of node n_i and deletes the deleted neighbors in the received RREQ packet.

iii) If the number of neighbor is 0 then the node does nothing.

Due to the case ii and case iii this method reduces the overhead of neighbor list listed in the RREQ packet.

The performance is evaluated for the proposed mechanism using the following performance metric.

Normalized routing overhead is defined as the ratio of the total packet size of control packets including RREQ, RREP, RERR and Hello packet to the total packet size of data packets delivered to the destinations. The size of RREQ packets is used instead of the number of RREQ packets, since the protocols include a neighbor list in the RREQ packet so that its size is bigger than the original AODV.

5.1 Simulation Parameters

The simulation is conducted using Network Simulator – NS2. The simulation parameters are tabulated in Table.1

TABLE1
SIMULATION PARAMETERS

SIMULATION PARAMETER	VALUES
Simulator	NS-2 (v2.34)
Topology Size	800m x 800m
Number of nodes	80,90,100,150
Bandwidth	2Mbps
Transmission Range	250m
Interface Queue Length	50
Traffic Type	CBR (Constant Bit Rate)
Packet Size	512 bytes
Pause Time	200µs

The MAC layer protocol uses the Distributed Coordination Function (DCF) of IEEE 802.11 protocol. The radio channel model is Lucent's WaveLAN. The traffic type used is

International Journal Of Scientific & Engineering Research, Volume 5, Issue 3, March-2014
ISSN 2229-5518

Constant Bit Rate (CBR) and the source- destination connection is chosen randomly.

The initial simulation for AODV protocol shows the following result for routing overhead in Figure 2.

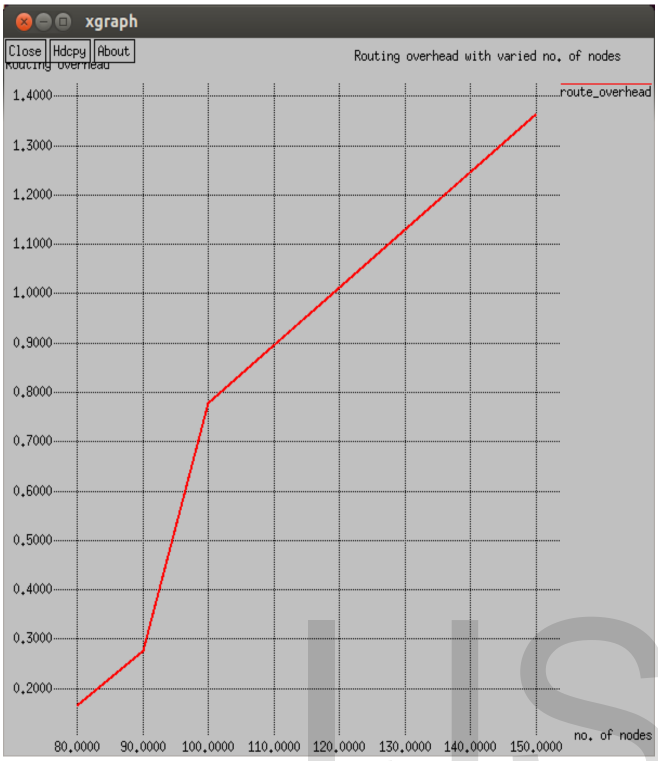

Fig. 2. Routing Overhead

The AODV protocol is modified to implement the PRNK mechanism and the results are compared between the AODV protocol and the proposed mechanism.

6 Conclusion

Broadcasting is the basic mechanism used in reactive routing protocols. The important issue is to reduce the number of rebroadcast packets. This paper proposes a new Rebroadcast Technique for Reducing Routing Overhead in Mobile Ad Hoc Networks (MANETs). The neighbor coverage knowledge comprises of coverage ratio and the connectivity factor. This technique dynamically calculates the rebroadcast delay, which finds the forwarding order and also effectively find the neighbor coverage knowledge. The result of the simulation shows that the new mechanism produces less rebroadcast than the existing protocol. Due to less redundant rebroadcast, the proposed mechanism reduces the network collision and contention so that it may also increases the packet delivery ratio and also decreases the average end-to-end delay. The simulation result shows that the new mechanism has better performance when the network is in high density. The future work is focused on calculating the result for performance metrics like MAC collision rate.

References

[1] 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.-5, 2009.

[2] 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.

[3] 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.

[4] 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.

[5] Z. Haas, J.Y. Halpern, and L. Li, "Gossip-Based Ad Hoc Routing," *Proc. IEEE INFOCOM*, vol. 21, pp. 1707-1716, 2002.

[6] 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, 2007.

[7] A. Keshavarz-Haddady, V. Ribeirox, 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.

[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] 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.

[10] Nelson, Shoji Yutaka, Takahashi.2010. Dynamic Hello/Timeout timer adjustment in routing protocols for reducing overhead in MANETs

[11] 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.

[12] W. Peng and X. Lu, "On the Reduction of Broadcast Redundancy in Mobile Ad Hoc Networks," *Proc. ACM MobiHoc*, pp. 129-130, 2000.

[13] C. Perkins, E. Belding-Royer, and S. Das, Ad Hoc On-Demand Distance Vector (AODV) Routing, 2003.

[14] 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.

[15] B. Williams and T. Camp, "Comparison of Broadcasting Techniques for Mobile Ad Hoc Networks," *Proc. ACM MobiHoc*, pp. 194- 205, 2002.

International Journal Of Scientific & Engineering Research, Volume 5, Issue 3, March-2014
ISSN 2229-5518

[16] 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.
[17] 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.
[18] An Improved Rebroadcast Probability Function for an Efficient Counter-Based Broadcast Scheme in MANETs
[19] *The Network Simulator (NS2)* website, http://www.isi.edu/nsnam/ns/ns-build.html
[20] The "*Network Simulator*" manual, www.isi.edu/nsnam/ns/ns-documentation.html