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A Neighbor Coverage based Probabilistic Rebroadcast for Reducing Routing Overhead in Mobile Ad hoc Networks

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Abstract: ***Mobile ad hoc networks consist of a collection of mobile nodes which can move freely. These nodes can be dynamically self-organized into arbitrary topology networks without a fixed infrastructure. Due to high mobility of nodes in mobile ad hoc networks, there exist frequent link breakages which lead to frequent path failures and route discoveries. The overhead of a route discovery cannot be neglected. We propose neighbor coverage based probabilistic rebroadcast protocol for reducing routing overhead in MANETs. In order to effectively exploit the neighbor coverage knowledge, we propose a novel rebroadcast delay to determine the rebroadcast order, and then we can obtain the more accurate additional coverage ratio by sensing neighbor coverage knowledge.***

Keywords: Mobile ad hoc networks; Neighbor Coverage; Network Connectivity; Probabilistic Rebroadcast; Routing Overhead.

1. Introduction

The Mobile Ad hoc Networks (MANETS) is a special type of wireless mobile network in which mobile hosts can communicate without any aid of established infrastructure and can be deployed for many applications such as battlefield, disaster relief and rescue, etc. The nodes are free to move randomly and act as end points as well as routers to forward packets in a multi-hop environment where all nodes may not be within the transmission range of the source. The network topology may change rapidly and unpredictably in time. New nodes can join the network, and other nodes may leave the network. The

Expected size of a MANET is larger than the transmission range of the nodes, because of this fact it is necessary to route the traffic through a multi-hop path for giving the nodes the ability to communicate with each other. There exist neither fixed routers nor fixed locations for the routers nor centralized administration. The lack of any fixed infrastructure is compensated by the routing ability of every mobile node. They all act as mobile routers and for this they need the capability to discover and maintain routes to every node in the network and to route the packets accordingly.

To optimize the broadcasting, limiting the number of rebroadcasting in the routing will help. Rebroadcasting delay helps to define the neighbor coverage knowledge in network, in order to strengthen the network connectivity, broadcasting neighbors should receive the RREQ packet these reduce the redundant and number of rebroadcasts of the RREQ packet in the data transmission. Always neighbor selection has to done randomly, due to random mobility model in network. Number of collisions in re-broadcasting will occur in the physical layer. Since data packets and routing packets share the same physical channel, the collision possibility is high when there is a large number of routing packets (request / response).

2. Related Work

Broadcasting is an effective tool for route discovery, but the routing overhead related to the broadcasting can be quite large, especially in highly dynamic and mobile networks.[2] and [3] Studied the broadcasting protocol experimentally and has shown that the rebroadcast is very expensive and consumes too much network resource. In highly dynamic and mobile networks, broadcasting is an effective tool for route discovery, but the routing overhead related with each broadcasting can be large. Ni et al. [3] has studied the broadcasting protocol analytically and experimentally and has concluded that the rebroadcast is very expensive and it consumes network resource heavily. The problems such as redundant retransmissions, contentions and collisions are caused by large routing overhead. Thus, optimizing the broadcasting in a route discovery is essential to improve the routing performance in MANET. Haas et al. [4] has proposed a gossip based approach, where each mobile node forwards a packet with a probability. They concluded that gossip-based approach can save up to 35 percent overhead compared to the flooding. However, the improvement of gossip-based approach is limited [2] when the network density is high or the traffic load is heavy. Abdulai et al. [5] has proposed a Dynamic Probabilistic Route Discovery (DPR) scheme and it is based on neighbor coverage. In this approach the forwarding probability is determined by each node according to the number of its neighbors and the set of neighbors which have been covered by the previous broadcast. This approach only considers the coverage ratio by the previous node and it has not considered the neighbors receiving the duplicate RREQ packet. Thus, there is a chance of further optimization of the DPR protocol.

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3. Proposed System

This System proposes a novel scheme is 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 rebroadcasts a packet, then more common neighbors will know this fact. Therefore, this rebroadcast delay enables the information that the nodes have transmitted the packet spread to more neighbors. This is performed by using the Neighbor Knowledge Probabilistic Rebroadcast Protocol (NCPR) based on the neighbor knowledge method. Therefore through this protocol one is, in order to effectively exploit the neighbor coverage knowledge, we need a novel rebroadcast delay to determine the rebroadcast order. Another one is, in order to keep the network connectivity and reduce the redundant retransmissions, need a metric named connectivity factor to determine how many neighbors should receive the RREQ packet. By combining the coverage ratio and the connectivity factor, the rebroadcast probability occurs, which can be used to reduce the number of rebroadcasts of the RREQ packet, to improve the routing performance. Advantages of proposed system are:

- Increase in packet delivery ratio.
- Decrease in the average end -to -end delay Transmissions.
- Reduce in Frequent link breakages and path failures leads to good routing performance when the network is in high density.
- Routing and mobility management should be maintained.

4. Algorithm Description

Our algorithm is described in the following steps:

1) When node receives an RREQ packet from its previous node, it can use the neighbor list in the RREQ packet to estimate how many its neighbors have not been covered by the RREQ packet from previous node.
2) If node has more neighbors uncovered by the RREQ packet from previous node, which means that if node rebroadcasts the RREQ packet, the RREQ packet can reach more additional neighbor nodes.
3) When a neighbor receives an RREQ packet, it could calculate the rebroadcast delay according to the neighbor list in the RREQ packet and its own neighbor list.
4) After determining the rebroadcast delay, the node can set its own timer.
5) If node receives a duplicate RREQ packet from its neighbor node, it knows that how many its neighbors have been covered by the RREQ packet from neighbor node. Thus, node could further adjust its UCN set according to the neighbor list in the RREQ packet from neighbor node.
6) After adjusting the Uncovered Neighbors set, the RREQ packet received from node is discarded.
7) When the timer of the rebroadcast delay of node expires, the node obtains the final UCN set. The nodes belonging to the final UCN set are the nodes that need to receive and process the RREQ packet.
8) Calculate the additional coverage ratio which is the ratio of the number of nodes that are additionally covered by this rebroadcast to the total number of neighbors of node.
9) Calculate connectivity factor which is the ratio of the number of nodes that need to receive the RREQ packet to the total number of neighbors of node.
10) Combining the additional coverage ratio and connectivity factor, we obtain the rebroadcast probability of node.

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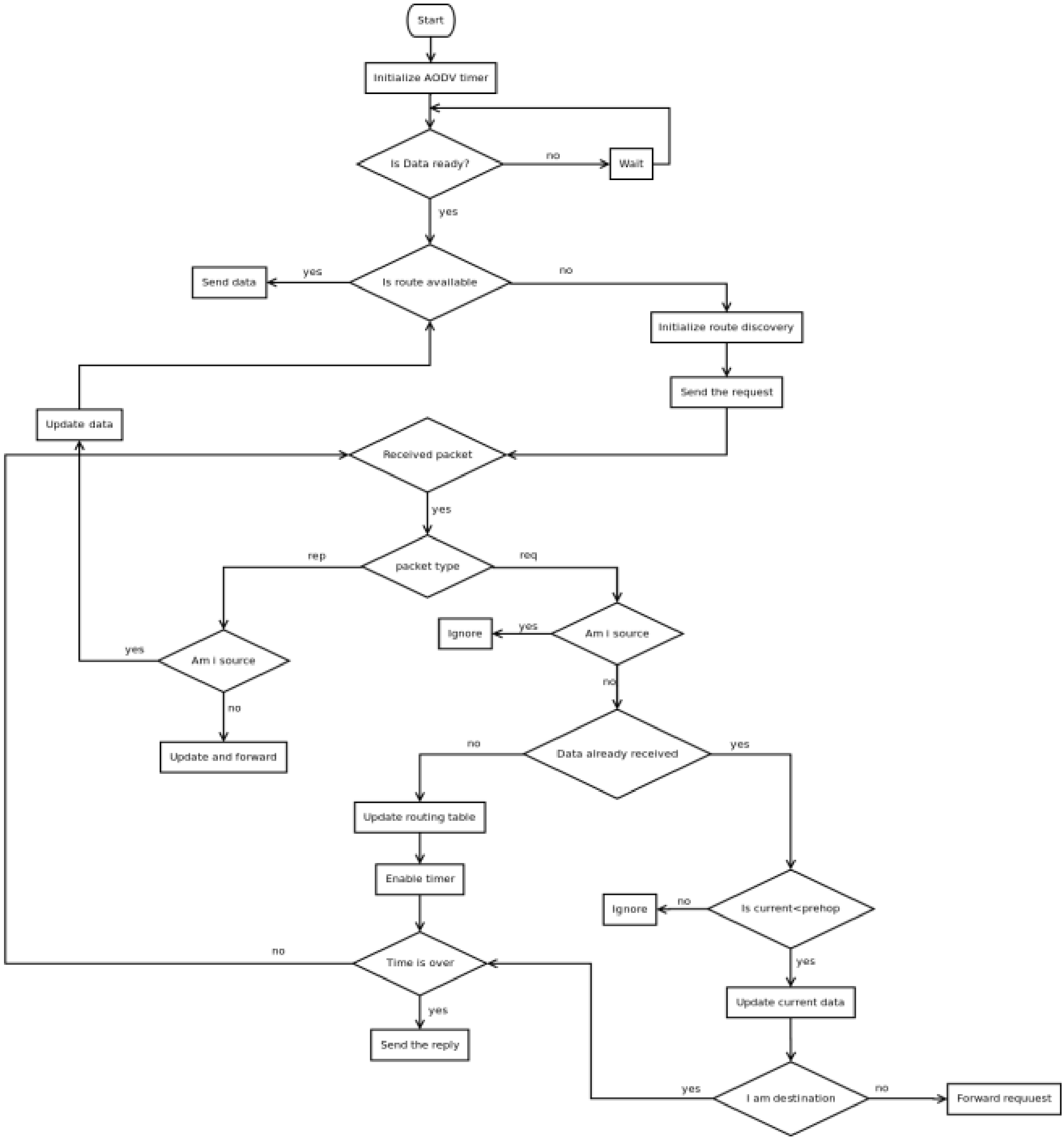
5. Flow Chart



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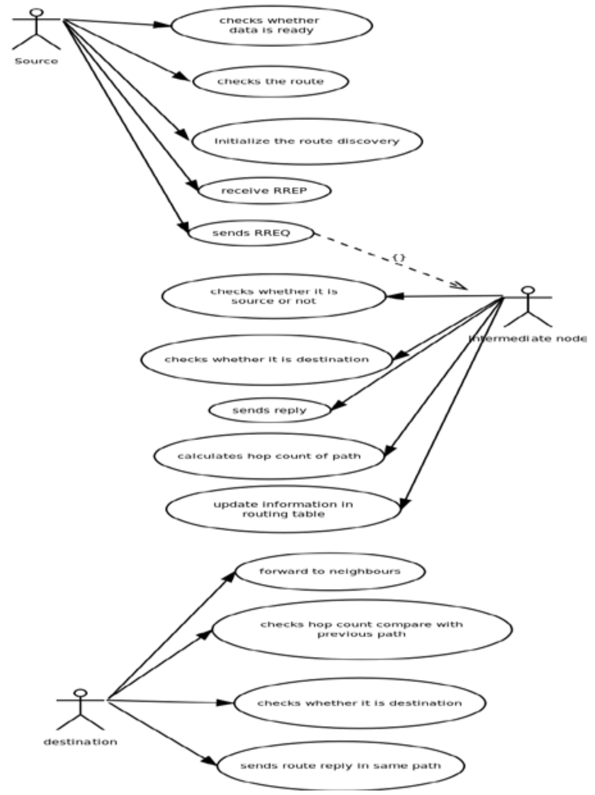
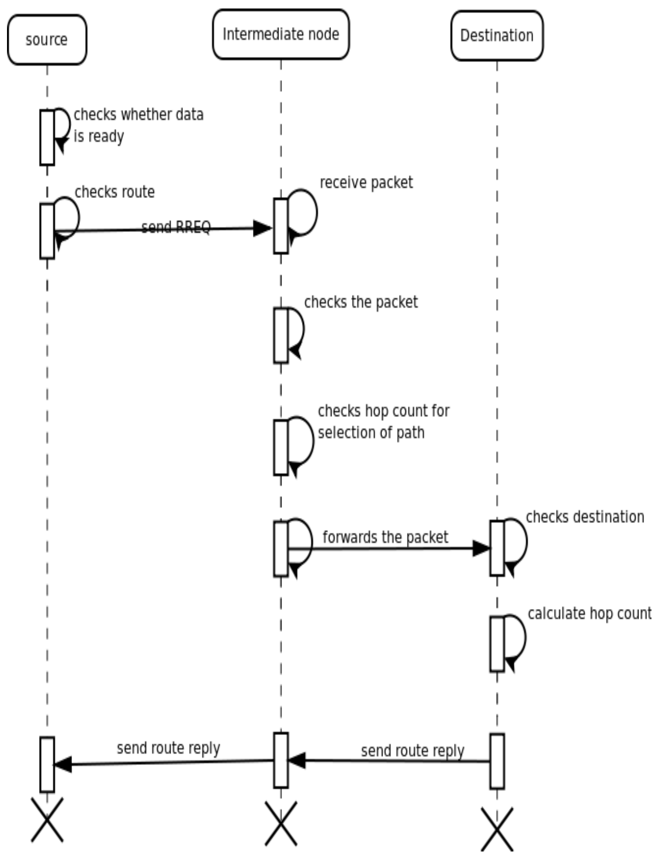
UML DIAGRAM



USE CASE



SEQUENCE

6. Probabilistic Rebroadcast Protocol

In this section we are discussing how to calculate rebroadcast delay and rebroadcast probability of the Probabilistic Rebroadcast (PR) protocol, which is based on neighbor coverage [1]. PR protocol has been proposed for reducing the routing overhead in highly dynamic network. Other protocols like AODV and DPR have been proposed for MANET and they improve the scalability of MANET but due to high mobility of node in MANET they are limited. We have proposed PR protocol to improve the performance of node in high dynamic and heavy loaded traffic network.

A. Calculation of Uncovered Neighbors Set and Rebroadcast Delay.

When node n_i receives RREQ packet from its neighbor node s, it can use the neighbor list available in the RREQ packet to calculate how many its neighbors have not been covered by the RREQ packet which has been delivered from node s. If node n_i has more neighbors uncovered by the RREQ packet from node s, which means that if node n_i rebroadcasts the RREQ packet, this RREQ packet could reach more extra neighbor nodes. We calculate the Uncovered Neighbors set $U(n_i)$ of node n_i as follows:

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

We obtain the initial UCN set. Due to broadcast characteristics of RREQ packet, node n_i can receive the redundant RREQ packets from its neighbors. Node n_i could further adjust the $U(n_i)$ with the neighbor knowledge. Where $N(s)$ and $N(n_i)$ are the neighbors sets of node s and n_i respectively. S is the node which sends the RREQ packet to node n_i.The Rebroadcast delay $T_d(n_i)$ of node n_i is calculated as follows:

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

$$T_d(n_i) = MaxDelay \times T_p(n_i)$$

Where $T_p(n_i)$ is the delay ratio of node n_i and MaxDelay is a Small constant delay.| | is the number of elements in a set.

B. Calculation of Neighbor Knowledge and Rebroadcast Probability.

If node n_i receives a redundant RREQ packet from its neighbor n_j then node n_i can further adjust its UCN set according to the neighbor list in the RREQ packet from n_j. Then $U(n_i)$can be adjusted as follows:

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

After adjusting the $U(n_i)$, the RREQ packet received from n_j is discarded. The rebroadcast probability is composed of additional coverage ratio and connectivity factor. Additional coverage ratio $R_a(n_i)$ of node n_i is defined as follows:

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

This formula indicates the ratio between the number of nodes that are additionally covered by this rebroadcast to the total number of neighbors of node n_i. $F_c(n_i)$ is defined as a connectivity factor as follows:

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$$F_c(n_i)= N_c|N(n_i)|$$

Where N_c=5.1774 log n, and n is the number of nodes in the network. The rebroadcast probability $P_{re}(n_i)$ of node n_i as follows:

$$P_{re}(n_i) = F_c(n_i) \times R_a(n_i)$$

Where, if the $P_{re}(n_i)$ is greater than 1, we set the $P_{re}(n_i)$ to 1.

7. Protocol Implementation and Performance Evalution

7.1 Protocol Implementation

To modify the source code of AODV in NS-2 to implement the proposed protocol. The proposed NCPR protocol needs Hello packets to obtain the neighbor information, and also needs to carry the neighbor list in the RREQ packet. Therefore, in 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, periodical Hello mechanism was not used. Since a node sending any broadcasting 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 .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. For sending or forwarding of RREQ packets, the neighbor table of any node n_i has the following 3 cases:

1) 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.
2) 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 neighbours 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 n_i can take their actions according to the value of neighbors in the received RREQ packet:

1) 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.
2) 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.
3) If the num neighbor 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.

7.2 Simulation Environment

In order to evaluate the performance of the proposed NCPR protocols compare it with some other protocols using the NS-2 simulator. Broadcasting is a fundamental and effective data dissemination mechanism for many applications in MANETs. In this paper, just study one of the applications, route request and route discovery. In order to compare the routing performance of the proposed NCPR protocol, choose the Dynamic Probabilistic Route Discovery (DPR) protocol which is an optimization scheme for reducing the overhead of RREQ packet incurred in route discovery in recent literature, and the conventional AODV protocol.

8. Experiments and Results

8.1 Performance with Varied Number of Node

In the conventional AODV protocol, the massive redundant rebroadcast incurs many collisions and interference, which leads to excessive packets drop. This phenomenon will be more severe with an increase in the number of nodes. It is very important to reduce the redundant rebroadcast and packet drops caused by collisions to improve the routing performance. Compared with the conventional AODV protocol, the NCPR protocol reduces the collision rate by about 93% on the average. Under the same network conditions, the collision rate is reduced by about 62% when the NCPR protocol is compared with the DPR protocol. This is the main reason that the NCPR protocol could improve the routing performance.

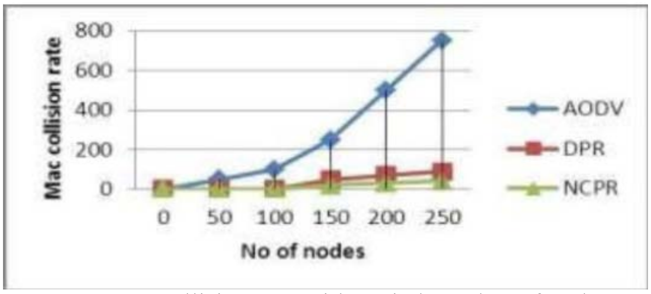

Figure 1: Collision rate with varied number of nodes

Fig. 2 shows the normalized routing overhead with different network density. The NCPR protocol can significantly reduce the routing overhead incurred during the route discovery, especially in dense network. Then, the RREQ traffic is reduced. In addition, for fairness, the statistics of normalized routing overhead includes Hello traffic. Even so, the NCPR protocol still yields the best performance, so that the improvement of normalized routing overhead is considerable. On average, the overhead is reduced by about 45.9% in the NCPR protocol compared with the conventional AODV protocol. Under the same network conditions, the overhead is reduced by about 30.8% when the NCPR protocol is compared with the DPR protocol. When network is dense, the NCPR protocol reduces overhead by about 74.9% and 49.1% when compared with the AODV and DPR protocols, respectively. This result indicates that the NCPR protocol is the most efficient among the three protocol.

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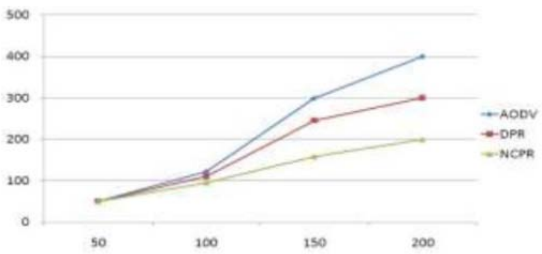

Figure 2: Normalized routing overhead with varied number of nodes

8.2 Performance with Varied Random Packet Rate

Fig. 3 shows the effects of the packet loss rate on the Collision rate. The DPR and NCPR protocols do not consider robustness for packet loss, but they can reduce the redundant rebroadcast and alleviate the channel congestion, thus, both of them have the lower packet drops caused by collisions than the conventional AODV protocol. Compared with the conventional AODV protocol, the NCPR protocol reduces the collision rate by about 93% on the average. In the same network density and traffic load, But in different packet loss rate, the collision rate is reduced by about 62% when the NCPR protocol is compared with the DPR Protocol.

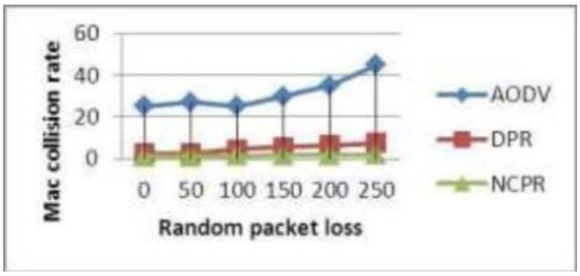

Figure 3: Collision rate with varied random packet loss rate

Figure 4: Overhead comparison for AODV and proposed NCPR protocol

We can practically see that the NCPR protocol reduces the routing overhead in the mobile ad-hoc networks.

Figure 5: Loss comparison of AODV and NCPR protocol

The proposed NCPR protocol reduces the information loss in the packets transmitted from source to destination and so we can say that NCPR protocol gives better results of transmission than the AODV protocol.

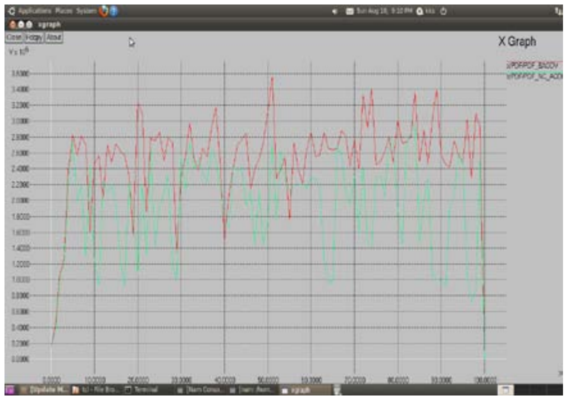

Figure 6: performance delay fraction of the AODV and NCPR protocol

9. Conclusion

In this paper, we have proposed a Probabilistic Rebroadcast protocol, which is based on Neighbor coverage for reducing the routing overhead in mobile ad hoc networks. We have also proposed a new scheme for dynamically calculating the rebroadcast delay and it is used to determine the forwarding order and exploit the neighbor coverage knowledge. When the network is dense, the PR protocol increases the packet delivery ratio when compared with the AODV. The Proposed protocol reduces the network collision, the average end-to-end delay and contention by reducing the number of redundant rebroadcast, so as to increase the packet delivery ratio. The simulation results have shown that the proposed protocol has good performance compared to AODV protocol when the network traffic is heavy loaded.

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