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A Neighbor Coverage-Based Probabilistic Rebroadcast for Reducing Routing Overhead in Mobile Ad Hoc Networks

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Abstract—Due to high mobility of nodes in mobile ad hoc networks (MANETs), there exist frequent link breakages which lead to frequent path failures and route discoveries. The overhead of a route discovery cannot be neglected. In a route discovery, broadcasting is a fundamental and effective data dissemination mechanism, where a mobile node blindly rebroadcasts the first received route request packets unless it has a route to the destination, and thus it causes the broadcast storm problem. In this paper, we propose a 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. We also define a connectivity factor to provide the node density adaptation. By combining the additional coverage ratio and connectivity factor, we set a reasonable rebroadcast probability. Our approach combines the advantages of the neighbor coverage knowledge and the probabilistic mechanism, which can significantly decrease the number of retransmissions so as to reduce the routing overhead, and can also improve the routing performance.

Keywords—*Mobile ad hoc networks, neighbor coverage, probabilistic rebroadcast, routing overhead*

1. INTRODUCTION

A mobile ad hoc network (MANET)[1] is a self organizing network comprising a set of wireless mobile nodes that move around freely and can able to communicate among themselves using wireless radios, without the aid of any centralized administration. In adhoc networks all nodes are mobile and can be connected dynamically in an arbitrary manner and can act as sender, receiver and even as a router at the same time. These nodes can be dynamically self-organized into arbitrary topology networks without a fixed infrastructure. Ad hoc routing protocols can be classified into three main categories based on the number of senders and receivers in group computing environment: Unicast, Multicast and Broadcast routing protocols. In unicast routing the communication is simply one-to-one i.e. a separate transmission stream from source to destination for each recipient. Multicast communications are both one-to-many and many-to-many traffic pattern i.e. to transmit a single message to a selective group of recipients where as in broadcast routing communications is one-to-all traffic pattern. It is a basic mode of operation in wireless medium that provides important control and route establishment functionality for a number of on-demand unicast and multicast protocols. When designing broadcast protocols for ad hoc networks, developers seek to reduce the overhead such as collision and retransmission or redundant retransmission, while reaching all the network's nodes.

One of the fundamental challenges of MANETs is the design of dynamic routing protocols with good performance and less overhead. Many routing protocols, such as Ad hoc On-demand Distance Vector Routing (AODV) and Dynamic Source Routing (DSR)[1], have been proposed for MANETs. The above two protocols are ondemand routing protocols, and they could improve the scalability of MANETs 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 [3] 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. In a route discovery [2], broadcasting is a fundamental and effective data dissemination mechanism, where a mobile node blindly rebroadcasts the first received route request packets unless it has a route to the destination, and thus it causes the broadcast storm problem.

The conventional on-demand routing protocols use the simple flooding to discover a route. They broadcast a Route REQuest (RREQ) packet to the networks, and the broadcasting induces excessive redundant retransmissions of RREQ packet and causes the broadcast storm problem, which leads to a considerable number of packet collisions, especially in dense networks. Therefore, it is indispensable to optimize this broadcasting mechanism. Some methods have been proposed to optimize the broadcast problem in MANETs in the past few years. By Williams and Camp categorized broadcasting protocols into four classes: "simple flooding, probability-based methods, area-based methods, and neighbor knowledge methods".

In simple flooding, source node first broadcasting a packet to all neighbors. It is forwarded by every neighbor in the network exactly once until all reachable network nodes have received that packet. Though simple flooding ensures the entire coverage, it has the largest forward node set and may cause broadcast storm problem in the network. Probability and area-based methods are proposed to solve the broadcast storm problem. They showed that an increase in the number of nodes in a static network will degrade the performance of the probability-based and area-based methods. Kim indicated that the performance of neighbor knowledge methods is better than that of area-based ones, and the performance of area-based methods is better than that of probability-based ones. For limiting the number of rebroadcasts can effectively optimize the broadcasting, and the neighbor knowledge methods perform better than the area-based ones and the probability-based ones, then propose a neighbor coverage-based probabilistic rebroadcast (NCPR) protocol [1]. Therefore,1.in order to effectively exploit the neighbor coverage knowledge, need a novel rebroadcast delay to determine the rebroadcast order, and then can obtain a more accurate additional coverage ratio. 2. 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. After that, by combining the additional coverage ratio and the connectivity factor, introduce a rebroadcast probability, which can be used to reduce the number of rebroadcasts of the RREQ packet, to improve the routing performance.

2. RELATED WORK

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 [5]. Perkins [1] studied routing protocols are proposed for Ad hoc networks and their classification of these schemes according to the routing strategy (i.e., table-driven and on-demand). Table-driven routing protocols, such as DSDV and OLSR, attempt to maintain consistent and up-to-date routing information from each node to every other node in the network. Each mobile node is required to periodically discover and maintain routes to every possible destination in the network. In the on-demand routing protocols, such as AODV and DSR, routes are discovered only when they are needed. Each node maintains a route for a source-destination pair without the use of periodic routing table exchanges or full network topological view.

Johnson [2] studied conventional on-demand routing protocols, a node that needs to discover a route to a particular destination, broadcasts a Route Request control packet (RREQ) to its immediate neighbors. Each mobile node blindly rebroadcast the received RREQ packet until a route is established. This method of route discovery is referred to as blind flooding. Blind flooding is extensively use in ad hoc, where a mobile node blindly rebroadcasts RREQ packets. This leads to packet collisions in network. In this paper generic Dynamic Probabilistic Method for route discovery is introduced, which is simple to implement and can reduce the overhead with dissemination of RREQs. The main problem is how to minimize the number of rebroadcast packets while good retransmission. Kim [4] proposed a probabilistic broadcasting scheme based on coverage area and neighbor confirmation. The scheme combines probabilistic approach with the area-based approach. A mobile host can dynamically adjust the value of the rebroadcast probability according to its additional coverage in its neighborhood. The coverage is estimated by the distance from the sender. Our scheme combines neighbor confirmation concept to prevent early die-out of rebroadcast. Abdulai [8] 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 neighbors receiving the duplicate RREQ packet.

Ni [3] studied the broadcasting protocol and simple packet flooding without a careful decision of a controlled rebroadcasting may produce an excessive redundancy of incoming packets, a greater channel contention, and a higher collision rate. Hybrid approaches is combining the advantages of distance-based and area-based schemes in terms of reachability and saving of rebroadcasting without the overhead and also satisfy two goals, namely high reachability and low redundancy. In our protocol, we also set a deterministic rebroadcast delay, but the goal is to make the dissemination of neighbor knowledge much quicker.

3. EXISTING SYSTEM

In the existing system, the conventional on-demand routing protocols use flooding to discover a route. They broadcast a Route REQuest (RREQ) packet to the networks, and the broad-casting induces excessive redundant retransmissions of RREQ packet and causes the broadcast storm problem, which leads to a considerable number of packet collisions, especially in dense networks. Therefore, it is indispensable to optimize this broadcasting mechanism. Some methods have been proposed to optimize the broadcast problem in MANETs in the past few years. Williams and Camp categorized broadcasting protocols into four classes: “simple flooding, probability-based methods, area-based methods, and neighbor knowledge methods.” For the above four classes of broadcasting protocols, they showed that an increase in the number of nodes in a static network will degrade the performance of the probability-based and area-based methods. Kim indicated that the performance of neighbor knowledge methods is better than that of area-based ones, and the performance of area-based methods is better than that of probability-based one. Disadvantages in existing system are:

- Routers may overloaded in a dense network leads to frequent link breakages and path failures occurs.
- Packet delivery does not take place in time, so reduce in packet delivery.
- Increase in end-to-end delay transmissions.
- Broadcast storm problem occurs due to number of packet collisions in dense network.

4. 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.

5. NEIGHBOR COVERAGE-BASED PROBABILISTIC REBROADCAST PROTOCOL

In this section, we calculate the rebroadcast delay and rebroadcast probability of the proposed protocol. We use 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 the rebroadcast probability in our protocol, which requires that each node needs its 1-hop neighborhood information.

5.1 Uncovered Neighbors Set and Rebroadcast Delay

When node n_i receives an RREQ packet from its previous node s, 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 s. If node n_i has more neighbors uncovered by the RREQ packet from s, which means that if node ni rebroadcasts the RREQ packet, the RREQ packet can reach more additional neighbor nodes. To quantify this, we define the UnCovered Neighbors set U (n_i) of node n_i as follows:

$$U(n_i) = N(n_i) - [N(n_i) \cap N(s)] - \{s\}, \quad (1)$$

where N(s) and N (n_i) are the neighbors sets of node s and n_i, respectively. s is the node which sends an RREQ packet to node n_i.

In order to sufficiently exploit the neighbor knowledge and avoid channel collisions, each node should set a rebroadcast delay. 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. The rebroadcast delay T_d (n_i) of node n_i is defined as follows:

$$T_p(n_i) = 1 - \frac{|N(s) \cap N(ni)|}{|N(s)|} \quad (2)$$

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

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.

The above rebroadcast delay is defined with the following reasons: First, the delay time is used to determine the node transmission order. When node s sends an RREQ packet, all its neighbors $n_{i,}$ $i = 1, 2 \ldots |N(s)|$ receive and process the RREQ packet. We assume that node nk has the largest number of common neighbors with node s, according to the above formula, node nk has the lowest delay. The objective of this rebroadcast delay is not to rebroadcast the RREQ packet to more nodes, but to disseminate the neighbor coverage knowledge more quickly.

If node n_i receives a duplicate RREQ packet from its neighbor n_j, it knows that how many its neighbors have been covered by the RREQ packet from n_j. Thus, UCN set according to the neighbor list in the RREQ packet from n_j. Then, the U (n_i) can be adjusted as follows:

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

After adjusting the U (n_i), the RREQ packet received from n_j is discarded. When the timer of the rebroadcast delay of node n_i expires, the node obtains the final UCN set. Note that, if a node does not sense any duplicate RREQ packets from its neighborhood, its UCN set is not changed, which is the initial UCN set. We define the additional coverage ratio (Ra (n_i)) of node n_i as :

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

This metric indicates the ratio of the number of nodes that are additionally covered by this rebroadcast to the total number of neighbors of node n_i. R_a becomes bigger, more nodes will be covered by this rebroadcast, and more nodes need to receive and process the RREQ packet, and, thus, the rebroadcast probability should be set to be higher. if each node connects to more than 5:1774 log n 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. Then, we can use 5.1774 log n as the connectivity metric of the network. We assume the ratio of the number of nodes that need to receive the RREQ packet to the total number of neighbors of node n_i is F_c (n_i). In order to keep the probability of network connectivity approaching 1, we have a heuristic formula: $|N(n_i)| \cdot F_c(n_i) \geq 5.1774 \log n$. Then, we define the minimum F_c (n_i) as a connectivity factor, which is:

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

where $N_c = 5.1774 \log n$, and n is the number of nodes in the network. From (5), we can observe that when $|N\ (n_i)|$ is greater than N_c, $F_c\ (n_i)$ is less than 1. That means node n_i is in the dense area of the network, then only part of neighbors of node ni forwarded the RREQ packet could keep the network connectivity. And when $|N\ (n_i)|$ is less than Nc, $F_c\ (n_i)$ is greater than 1. That means node ni is in the sparse area of the network, then node ni should forward the RREQ packet in order to approach network connectivity. Combining the additional coverage ratio and connectivity factor, we obtain the rebroadcast probability $P_{re}\ (n_i)$ of node n_i:

$$P_{re}\ (n_i) = F_c\ (n_i)\ .\ R_a\ (n_i) \qquad (6)$$

where, if the $P_{re}\ (n_i)$ is greater than 1, we set the $P_{re}\ (n_i)$ to 1. Note that the calculated rebroadcast probability $P_{re}\ (n_i)$ may be greater than 1, but it does not impact the behavior of the protocol. It just shows that the local density of the node is so low that the node must forward the RREQ packet. Then, node n_i need to rebroadcast the RREQ packet received from s with probability $P_{re}\ (n_i)$.

6. CONCLUSION

In this paper, we proposed a probabilistic rebroadcast protocol based on neighbor coverage to reduce the routing overhead in MANETs. This neighbor coverage knowledge includes additional coverage ratio and connectivity factor. We proposed a new scheme to dynamically calculate the rebroadcast delay, which is used to determine the forwarding order and more effectively exploit the neighbor coverage knowledge. Simulation results show that the proposed protocol generates less rebroadcast traffic than the flooding and some other optimized scheme in literatures. Because of less redundant rebroadcast, 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. The simulation results also show that the proposed protocol has good performance when the network is in high density or the traffic is in heavy load.

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