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PROBABILISTIC BASED REBROADCAST TO IMPROVE PERFORMANCE IN MOBILE AD HOC NETWORKS

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ABSTRACT

Mobile Ad-hoc Networks (MANETs) are future wireless networks consisting entirely of mobile nodes that communicate on-the-move without base stations. 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 Ad hoc Traversal Routing protocol (ATR) for reducing routing overhead in MANETs.

KEYWORDS: Mobile ad hoc networks, Ad hoc Traversal Routing protocol(ATR), network connectivity, probabilistic rebroadcast, routing overhead .Ad hoc On-demand Distance Vector Routing (AODV) ,Dynamic Probabilistic Route Discovery (DPR) , Neighbor coverage-based probabilistic rebroadcast (NCPR) .

1 .INTRODUCTION

The remarkable technology of wireless networks started in late 1970s and the interest has been growing ever since. Earlier, information sharing between various communication devices was difficult, as the users need to set up static, bi-directional links between the devices to perform various administrative tasks. In order to prevent the difficulty in maintaining these infrastructure based networks, various techniques have been determined leading to ad hoc networks. In Adhoc Networks, there is no infrastructure, which makes it easily deployable and connects the communication devices (nodes) within no time. Such interconnection between mobile nodes is called a Mobile Ad hoc Network (MANET). Mobile ad hocnetwork is an autonomous and decentralized network in which any mobile node can freely move in andout of the network. These mobile nodes must act as both host and router in which both route discovery mechanism and data transmission between nodes is handled by the mobile nodes itself. These nodes have the ability to configure themselves and because of their self-configuring capability, they can form an arbitrary network when needed without the basis of any fixed infrastructure. Due to these characteristics, the network topology gets varied more frequently and hence a routing protocol must be efficient enough in delivering an ameliorated network performance. Traditional routing protocols used for wired networks cannot be employed for mobile ad hoc networks because the basic idea of such ad hoc networks is mobility with dynamic topology [Janne Lundberg et al, 2014]. Routing protocols plays a major role in such type of networks whose function is to transfer data packets between the mobile nodes efficiently tackling all the varying situations.

Many routing protocols, such as Ad hoc On-demand Distance Vector Routing (AODV) [1] and Dynamic

Probabilistic Route Discovery (DPR) [2],Neighbor coverage-based probabilistic rebroadcast (NCPR) have been proposed for MANETs. The above protocols are on demand routing protocols, and they could improve the scalability of MANETs by limiting the routing overhead when a new route is requested [3]. 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.

In this paper we proposed a protocol known as Ad hoc Traversal Routing Protocol (ATR). Therefore, 1) 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 accurate additional coverage ratio; 2) 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.

The main contributions of this approach are as follows:

1.) To calculate the rebroadcast delay. The rebroadcast delay is to determine the forwarding order. The node which has more common neighbours with the previous node has the lower delay. If this node rebroadcasts a packet, then more common neighbours will know this fact.
2.) 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. 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; and b. connectivity factor, which reflects the relationship of network connectivity and the number of neighbors of a given node.

2 .RELATED WORKS :

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].Ni et al. [4] studied the broadcasting protocol analytically and experimentally, and showed that the rebroadcast isvery costly and consumes too much network resource. The broadcasting incurs large routing overhead and causes many problems such as redundant retransmissions, contentions and collisions [4]. Thus, optimizing the broadcasting in route discovery is an effective solution to improve the routing performance. Haas et al. [6] 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 [5]. Kim et al. [7] proposed a probabilistic broadcasting scheme based on coverage area and uses the neighbor confirmation to guarantee reach ability. Peng and Lu [8] 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. Abdulai et al. [9] 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 but the previous node, and it does not consider the neighbors 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. [10] 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. [11] proposed two deterministic timer-based broadcast schemes: Dynamic Reflector Broadcast (DRB) and Dynamic Connector-Connector Broadcast(DCCB).

They presented a new perspective for broadcasting : Neighbor coverage-based probabilistic rebroadcast (NCPR) in which we also set a deterministic rebroadcast delay, but the goal is to make the dissemination of neighbor knowledge much quicker.

3.Ad Hoc TRAVERSAL ROUTINGPROTOCOL :

Ad hoc Traversal Routing is an Inter-domain Routing for Heterogeneous Mobile Ad Hoc Networks UsingPacket Conversion and Address Sharing. In ad hoc networks, a diversity of routing protocols exists. Each networkselects a routing protocol suitable for its own environment such as a vehicular ad hoc network (VANET), a wireless mesh network, or a mobile ad hoc network (MANET) that consists of pedestrians. Generally, since there is no interoperability between different routing protocols

in ad hoc networks, the communication between different networks is impossible. Therefore, in this paper, we propose Ad hoc Traversal Routing (ATR) to provide interoperability between different networks. Because of ATR, any two nodes in different networks can seamlessly communicate with each other. ATR connects two different networks to each other by converting control messages from one network to another network and adding the node address of different networks into the routing table for routing protocols. In addition, we conduct simulation experiments to evaluate the performance of ATR in heterogeneous wireless network environment that consists of a vehicle ad hoc network, a wireless mesh networks, and a mobile ad hoc network.

3.1 ALGORITHM DESCRIPTION :

The formal description ofAd hoc Traversal Routing for reducing routing overhead in route discovery is shown in algorithm 1.

Definitions -

RREQv : RREQ packet received from node v,
Rv.id : the unique identifier (id) of RREQv,
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 (1) - ADTV

1: if n_i receives a new $RREQ_S$ from s then
2: Compute initial uncovered neighbors set $U(n_i, R_s.id$ for $RREQ_S)$
3: $U(n_i, R_s.id$ for $RREQ_S) = N(n_i) – [N(n_i) \eta N(s)] – \{s\}$
4: Compute the rebroadcast delay $T_d(n_i)$
5: $T_p(n_i) = 1 – [N(s) \eta N(n_i)]/[N(s)]$
6: $T_d(n_i) = MaxDelay * T_p(n_i)$
7: Set a timer $(n_i,R_s.id)$ according to $T_d(n_i)$
8: end if
9: while n_i receives a duplicate $RREQ_j$ fromn_j before timer$(n_i, R_s.id)$ expires do
10: Adjust $U(n_i, R_s.id)$
11: $U(n_i, R_s.id) = (n_i, R_s.id) – [U(n_i, R_s.id) \eta N(n_j)]$
12: discard $(RREQ_j)$
13: end while
14: if timer$(n_i, R_s.id)$ expires then
15: Compute the rebroadcast probability $P_{re}(n_i)$
16: $R_u(n_i) = [U(n_i, R_s.id)]/ N(n_i)]$
17: $F_c(n_i) = N_c / N(n_i)$
18: $P_{re}(n_i) = F_c(n_i) * R_u(n_i)$
19: if Random (0,1)≤ $P_{re}(n_i)$ then
20: broadcast $(RREQ_s)$
21: else
22: discard $(RREQ_s)$
23: end if
24: end if

4. PROTOCOL IMPLEMENTATION AND PERFORMANCE EVALUATION :

4.1 PROTOCOL IMPLEMENTATION :

We modify the source code of AODV in MATLAB to implement our proposed protocol. Note that the proposed ATR protocol needs Hello packets to obtain the neighbor 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 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. We use the following mechanism [12] 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 HelloInterval, the node needs to send a Hello packet. The value of HelloInterval 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 n_i has the following three cases:

- if the neighbor table of node n_i adds at least one new neighbor n_j, then node n_i 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 n_j may not have cached the neighbor information of node n_i, and, thus, node n_j needs the complete neighbor list of node n_i .
- if the neighbor table of node n_i deletes some neighbors, then node n_i 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_neighborsfield in the RREQ packet .
- if the neighbor table of node n_i does not vary, node n_i does not need to list its neighbors, and set the num_neighbors to 0.

4.2 PERFORMANCE :

In order to evaluate the performance of the proposed NCPR protocol, we compare it with some other protocols using MATLAB software.

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

- **MAC collision rate**: 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 destina-tions 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.

4.3 SIMULATION PARAMETERS :

The Distributed Coordination Function (DCF) of the IEEE 802.11 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. It 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 1000m × 1000m. In this mobility model, each node moves to a random selected destination with a random speed from a uniform distribution. After the node reaches its destination, it stops for a pause time interval and chooses a new destination and speed.

4.4 SIMULATION RESULTS :

Fig. 1 shows the effects of network density on the MAC collision rate. In the IEEE 802.11 protocol, the data and control packets share the same physical channel. It shows that ADTV has less collision rate when compare with the other three protocols.

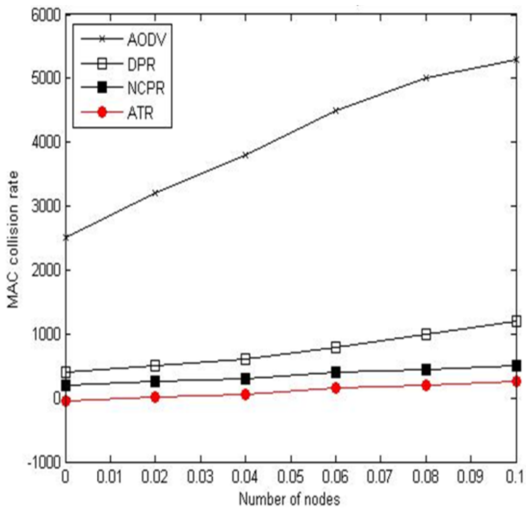

Fig. 1. MAC collision rate with varied number of nodes.

Fig. 2 shows the normalized routing overhead with different network density. The ATR protocol can significantly reduce the routing overhead incurred during the route discovery, especially in dense network. Although the ATR protocol increases the packet size of RREQ packets, it reduces the number of RREQ packets more significantly. Then, the RREQ traffic is still reduced. In addition, for fairness, the statistics of normalized routing overhead includes Hello traffic. This results indicates that the ATR protocol is the most efficient among the three protocols.

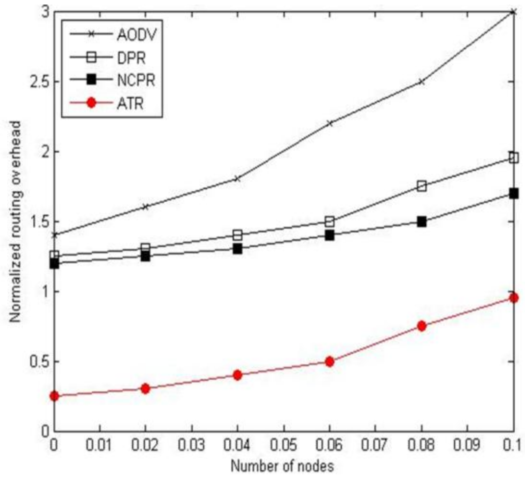

Fig.2.normalized routing overhead with varied number of nodes.

Fig.3 shows the packet delivery ratio with increasing network density. The ATR protocol can increase the packet delivery ratio because it significantly reduces the number of collisions, which is shown in Fig. 1, so that it reduces the number of packet drops caused by collisions .

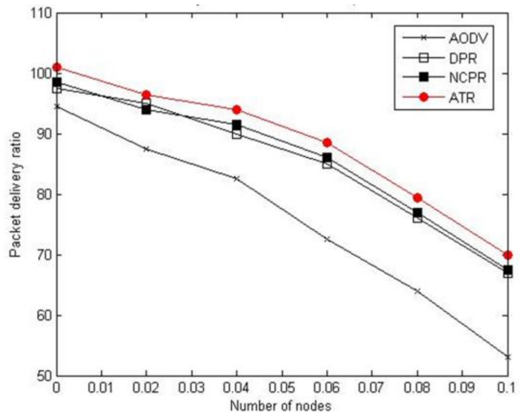

Fig. 3.Packet delivery ratio with varied number of nodes

Fig. 4 measures the average end-to-end delay of CBR packets received at the destinations with increasing net-work density. The ATR protocol decreases the average end-to-end delay due to a decrease in the number of redundant rebroadcasting packets. The redundant rebroadcast increases delay because 1) it incurs too many collisions and interference, which not only leads to excessive packet drops, but also increases the number of retransmissions in MAC layer so as to increase the delay; 2) it incurs too many channel contentions, which increases the backoff timer in MAC layer, so as to increase the delay. Thus, reducing the redundant rebroadcast can decrease the delay.

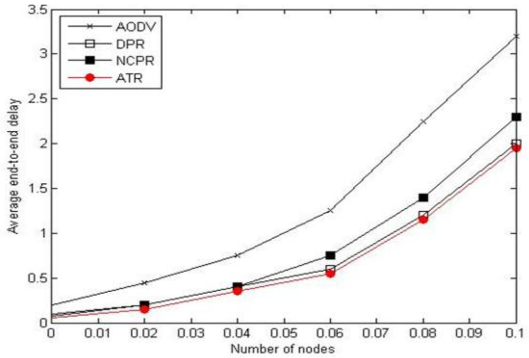

Fig. 4.Average end-to-end delay with varied number of nodes.

5. 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.

By adopting Ad hoc Traversal Routing we are getting less average end to end delay, more packet delivery ratio, less normalized routing overhead and less MAC collision rate by which performance of the system is going to increase.

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