Effective Usage of Rebroadcast Delay to Minimize Routing Overhead in MANET

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Abstract: Broadcasting is effective data dissemination mechanism for route discovery in Mobile Ad-hoc Network (MANET). Although it has many benefits, it also causes some problems such as the broadcast storm problem, which is pertaining to redundant retransmission, collision, and contention. Many techniques have been proposed to solve them but none of them guarantees the lowest bound. To overcome broadcast storm problem and reduce routing overhead, proposed system minimizes routing overhead using rebroadcast delay and rebroadcast probability. It also considers Nodes having highest energy will broadcast the RREQ packets to its neighbors. This system is implemented over the MANET network and simulated using Network Simulator (NS2). This project contributes that neighbor nodes of the failed link take the backup in case of link failure so as to decrease the number of retransmissions and minimizes routing overhead, also helps in improving the routing performance.

Keywords: Mobile Ad-hoc Network, neighbor coverage, routing overhead, link failure.

Introduction

A wireless ad-hoc network has features such as self configuring, self-maintenance and the deficiency of the need for fixed network infrastructures or centralized administration and inexpensive deployment. Nodes communicate with each other directly or through intermediate nodes. In MANET a node can act both as a host or a router. A traditional wired network doesn’t exhibit these features. A MANET system is a group of mobile (or temporarily stationary) devices which need to provide the ability to stream voice, data and video between arbitrary pairs of devices utilizing the others as relays to avoid the need for infrastructure. They dynamically change locations to form a network to exchange information. It doesn’t rely on pre-existing infrastructure. Because of the dynamic nature of nodes routing is a challenging issue in mobile ad hoc network.

Routing protocols are categorized into two categories Proactive and Reactive routing protocols. Ad-hoc On-demand Distance Vector Routing (AODV) [9], Dynamic Source Routing (DSR) [10] is reactive routing protocol. A node in reactive routing protocol minimizes routing overhead. They minimize it by only sending routing information as soon as the communication is initiated between them.

Conventional routing protocols use flooding technique to find route. In flooding source node broadcast a packet to all its neighbors. It causes redundant retransmission of RREQ and causes broadcast storm problem. Effective technique for route discovery is broadcasting. Broadcasting algorithms are classified into four categories such as simple flooding, probability-based, area-based and neighbor-knowledge methods. Neighbor-knowledge method’s performance is better than the others [11].

Due to mobile nature of nodes in MANET, continuously link breakage problem occur which causes path failures and finding of route. It leads to increase in routing overhead, increase in delay and reduction in packet delivery ratio. Hence, minimization of routing overhead in route discovery is an important problem in MANET.
Broadcasting optimization by controlling number of rebroadcast is motivation of the proposed system. To utilize the neighbor coverage knowledge efficiently, rebroadcast delay determines the rebroadcast order. To minimize the redundant retransmissions and to keep network connectivity and connectivity factor is used to determine how many neighbors should covered by transmission. Routing performance is improved using rebroadcast probability which reduces the number of RREQ packet broadcasting which improves the. In this way performance is increased [1].

An important contribution of this project is: If node is identified in the dense area, the node will not broadcast the RREQ packets. Thus nodes having highest energy will broadcast the RREQ packets to its neighbors. And in case of link failure, Source node has to discover another path to send the packet. In proposed system neighbor nodes of the failed link takes the backup and starts to send the packet.

Related Work
Conventional techniques to minimize routing overhead associated in route discovery:

Z. Haas, J.Y. Halpern, and L. Li proposed Gossip-based Ad-hoc Routing Method. Gossiping uses percolation theory. In high density network, there is limitation in gossip-based approach. Gossiping can save 35% message overhead other than flooding and also it can be used in almost any routing algorithm [2]. Robust Broadcast Propagation (RBP) protocol is proposed by Stann et al. which provides reliability for flooding in wireless networks. Reliable broadcasting is purpose of this algorithm. It provides more reliable broadcast by reducing the frequency of upper layer which improves the overall performance of flooding [6]. Dynamic Probabilistic Route Discovery Protocol (DPR) is discovered by J.D. Abdulai, M. Ould-Khaoua, L.M. Mackenzie, and A. Mohammed. In this approach, Node calculates forwarding probability according to the set of neighbors covered by the transmission and the characteristic of its node density .DPR gives high performance but in most cases, route discovery gives problem [3]. Alireza Keshavarz-Haddad, Vinay Ribeiro, Rudolf Riedi approached a scheme named as Dynamic Reflector Broadcast (DRB) and Dynamic Connector- Connector Broadcast (DCCB).It uses small number no of nodes. It guarantees full reachability [4].Wei Peng Xi-Cheng Lu proposed Scalable Broadcast Algorithm (SBA).Aim of this algorithm is to avoid unnecessary rebroadcasts by using information about local topology and duplicate broadcasts [5]. Kim et al. approaches a probabilistic broadcasting scheme based on coverage area and neighbor confirmation. Rebroadcast probability is set by using coverage area, and uses the neighbor confirmation to guarantee reachability [7].

Proposed Work
To minimize routing overhead proposed system uses rebroadcast delay and rebroadcast probability. The neighbor coverage based probabilistic rebroadcast protocol (NCPR) combines both neighbor coverage and probabilistic methods. Rebroadcast delay is needed in order to successfully utilize the knowledge about neighbor coverage, and to obtain the rebroadcast order. Then accurate additional coverage ratio is acquired. Connectivity factor verifies how many neighbors should receive the RREQ packet, for maintaining the network connectivity and reducing the redundant retransmissions. After that, Rebroadcast probability is established by combining the additional coverage ratio and the connectivity factor, for reducing the number of retransmissions of the RREQ packet and to improve the routing performance.

I. Architecture

![Architecture of System](image)

Every node in the network sends the beacon packets to each node in the transmission range. When a node receives the beacon packet it will reply including its information. Every node updates its neighbor list very often. After initialization of route discovery process, source node sends the RREQ packet to its neighbors.
A node which receives the RREQ packet, it compares the neighbor list with its sender neighbor list. And, it
determines the common neighbors. If node \( n_j \) has more neighbors which are not covered by the RREQ
packet from \( t \), if node \( n_j \) rebroadcasts the RREQ packet, packet can reach more additional neighbor nodes in
the network. Rebroadcasting is done based on nodes which are not able to receive the broadcast packet and
known as Uncovered Neighbors Set.

II. Rebroadcast Delay

To find the route between the source and destination the RREQ packet is broadcasted. Because of the
broadcast nature of an RREQ packet, nodes can receive duplicate RREQ packet from its neighbors. In order
to adequately exploit the neighbor knowledge every node should set a rebroadcast delay. Node transmission
order is determined by rebroadcast delay. If node \( n_j \) has more neighbors uncovered by the RREQ packet, it
means that if node \( n_j \) rebroadcasts the RREQ packet, that packet can reach more additional neighbor nodes.

In the proposed work, Uncovered Neighbors set \( U_n(n_j) \) of node \( n_j \) is calculated.

\[
T_p(n_j) = \frac{|N(t) \cap N(n_j)|}{|N(t)|} \quad (1)
\]

When node \( s \) sends an RREQ packet, all its neighbors \( n_j; j = 1; 2; . . . \) receive and process the RREQ
packet. Assume that node \( n_j \) has the largest number of common neighbors with node \( s \) then node \( n_j \) has
the lowest delay. Once \( n_j \) rebroadcasts the RREQ packet, there are more nodes to receive it, because a node \( n_j \)
has the largest delay. Timer is set according to the rebroadcast delay. When a node receives the duplicate
RREQ packet before expires the timer, it adjusts the UCN list.

III. Neighbor Knowledge and Rebroadcast Probability

There is no need to adjust rebroadcast delay. Final UCN set is obtained when the timer of the rebroadcast
delay expires. Final UCN set nodes are the nodes that need to receive and process the RREQ. If any node
does not sense any duplicate RREQ packets from its neighborhood then its UCN set can’t changed, which is
the initial UCN set. Final UCN set is used to set the rebroadcast probability.

Rebroadcast Probability is composed of two factors Additional coverage ratio and connectivity factor.

Additional coverage ratio:

\[
Ad(n_j) = \frac{|U(n_j)|}{|N(n_j)|} \quad (2)
\]

Coverage Ratio= Number of nodes that are additionally covered by this rebroadcast / Total number of
neighbors of node \( n_j \).

Nodes which are additionally covered by this rebroadcast need to receive and process the packet. As \( Ad \),
increases, more nodes will be covered by this rebroadcast. Thus more nodes need to receive and process the
RREQ packet so the rebroadcast probability should be set to be higher.

Connectivity factor:

\[
C_c(n_j) = \frac{N_c}{|N(n_j)|} \quad (3)
\]

Where \( N_c = 5.1774 \log n \), and \( n \) is the number of nodes in the network. If \( |N(n_j)| \) is greater than \( N_c \), then
node \( n_j \) is in the dense area of the network. Then only part of neighbors of node \( n_j \) forwarded the RREQ
packet could keep the network connectivity. And when \( |N(n_j)| \) is less than \( N_c \), \( C_c(n_j) \) is greater than 1. That
means node \( n_j \) is in the sparse area, then node \( n_j \) should forward the RREQ packet in order to approach
network connectivity. Rebroadcast probability \( Pr_e(n_j) \) of node \( n_j \) is obtained by combining additional
coverage ratio and connectivity factor:

\[
Pr_e(n_j) = C_c(n_j) . Ad(n_j) \quad (4)
\]

The parameter \( C_c \) is inversely proportional to the local node density. It means that if the local node
density is low, rebroadcast probability is increased by parameter \( C_c \). It will then increase the reliability of
the NCPR in the sparse area. Due to high local node density, the parameter \( C_c \) could further decrease the
rebroadcast probability. And further it increases the efficiency of NCPR in the dense area. So density
adaptation is added by parameter \( C_c \) to the rebroadcast probability.

If rebroadcast probability is less than the threshold value, the node will not broadcast the RREQ
packets, because the node is identified the dense area. Suppose due to the mobility of nodes are moving into
another location, in that situation the packets can’t reached to the destination. Therefore to solve this issue,
this project contributes a nodes having highest energy will broadcast the RREQ packets to its neighbors.

IV. Solution for Link Failure Problem

Due to mobility if node moves into another location, link failure occurs. Then source node has to discover
another path to send the packet. Proposed system contributes to solve this problem. In this case, neighbor
nodes of the failed link take backup starts to send the packet. It saves the time required for discovering another path.

**Implementation and Performance Evaluation**

**A. Simulation Model and Parameters**

NS-2 (v2.35) is used to implement proposed protocol. Each and every node moves to a random selected destination in mobility model with a random speed from a uniform distribution. Parameters used in this model are as under:

<table>
<thead>
<tr>
<th>Software for simulation</th>
<th>Network simulator 2.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel</td>
<td>Wireless</td>
</tr>
<tr>
<td>Simulation run time</td>
<td>50 seconds</td>
</tr>
<tr>
<td>Traffic Type</td>
<td>CBR</td>
</tr>
<tr>
<td>Packet size</td>
<td>1024bytes</td>
</tr>
<tr>
<td>Speed</td>
<td>1m/s to 10 m/s</td>
</tr>
<tr>
<td>Routing Protocol</td>
<td>AODV</td>
</tr>
<tr>
<td>Propagation model</td>
<td>TwoRayGround</td>
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<tr>
<td>Network Interface Type</td>
<td>Wireless Physical</td>
</tr>
<tr>
<td>Queue Type</td>
<td>Drop Tail</td>
</tr>
<tr>
<td>MAC Type</td>
<td>Mac/802.11</td>
</tr>
<tr>
<td>Antenna Type</td>
<td>Omni Antenna</td>
</tr>
</tbody>
</table>

**B. Performance Metrics**

**MAC collision rate**: The average number of packets dropped resulting from the collisions at the MAC layer per second.

**Normalized routing overhead**: Total packet size of control packets (RREQ, RREP, RERR, and Hello) /Total data packets packet size delivered to the destinations.

**Packet delivery ratio**: Number of data packets successfully received by the CBR destination /Number of data packets generated by the CBR sources.

**Average end-to-end delay**: The average delay of successfully delivered packets from source to destination. It contains all possible delays from the CBR source nodes to destination nodes.

**C. Results**

**MAC collision rate**: Compared with the AODV protocol, the NCPR protocol reduces the MAC collision rate by about 93.37 percent on the average. Under the same network conditions, the MAC collision rate is reduced by about 60.66 percent when the NCPR protocol is compared with the DPR protocol. This is the main reason that the NCPR protocol could improve the routing performance.
Normalized routing overhead: On average, the overhead is reduced by about 52.38 percent in the NCPR protocol compared with the conventional AODV protocol. Under the same network conditions, the overhead is reduced by about 26.59 percent when the NCPR protocol is compared with the DPR protocol.

Packet delivery ratio: The Packet Delivery Ratio of NCPR is very much greater than AODV & slightly greater than DPR. On average, the packet delivery ratio is improved by about 52.05 percent in the NCPR protocol when compared with the conventional AODV protocol. And in the same situation, the NCPR protocol improves the packet delivery ratio by about 37.25 percent when compared with the DPR protocol. The comparison is done by changing the number of nodes.
Average end-to-end delay: The comparison is done for end to end delay for MANET with three different protocols namely AODV, DPR and NCPR. For NCPR also the delay increases as the number of nodes increases gradually. Reducing the redundant rebroadcast can decrease the delay. On average, the end-to-end delay is reduced by about 65.82 percent in the NCPR protocol when compared with the conventional AODV protocol. Under the same network conditions, the delay is reduced by about 46.71 percent when the NCPR protocol is compared with the DPR protocol.

Conclusion

Broadcasting is a fundamental data dissemination mechanism for various Manets’ application. An arbitrary node movement in MANET leads to link breakage, path failure and route discoveries. It causes a number of rebroadcasts between nodes and causes routing overhead. Because of less redundant rebroadcast, this system mitigates the network contention and collision, so as to decrease end-to-end delay and increase the packet delivery ratio. The experimental result shows that this system has good performance over other methods. Furthermore this system reduces routing overhead, end-to-end delay and increases the packet delivery ratio, thus performance is improved.

References

[1]. En Bo Wang, Jing Jing Xia, and Dan Keun Sung Xin Ming Zhang, “A Neighbor Coverage-Based Probabilistic Rebroadcast for Reducing Routing Overhead in Mobile Ad Hoc Networks,” *IEEE TRANSACTIONS ON MOBILE COMPUTING*, vol. 12, MARCH 2013.


