ISSN 2278-3091

International Journal of Advanced Trends in Computer Science and Engineering, Vol.3 , No.4, Pages : 83-89 (2014)
Special Issue of ICCEIT 2014 - Held on September 01, 2014 in The Solitaire Hotel, Bangalore, India

An Improved Flooding Scheme for AODV Routing Protocol in MANETs

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***Abstract*— MANETs (Mobile Ad Hoc Networks) refers to a set of wireless mobile nodes that can communicate and move at the same time but without the aid of any centralized management or existing infrastructure such as base station. Each node will act as a router and can forward the data packets to other nodes. In MANETs (Mobile Ad Hoc Networks) broadcasting is an inevitable operation of route discovery. Though the broadcast by flooding is simple but inefficient and also results in redundant message relays. The normal flooding scheme cause high retransmissions which lead to packet collisions and media congestion that can significantly degrade the network performance and throughput. By knowing the geographical position of the mobile nodes, it can help the protocol to reduce the number of retransmissions, thus causing the enhancement of the protocol performance. The proposed flooding algorithm makes use of the nodes position to rebroadcast the packets and efficiently spread the control traffic in the mobile ad hoc network. The algorithm is applied on the Ad-hoc On Demand Distance Vector (AODV) routing protocol for the route discovery process to reduce the number of Route Request (RREQ) messages propagating through the network. The Route Request (RREQ) has been customized by assigning a list to the Route Request (RREQ) contain fourth Nominated Neighbors to Rebroadcast the RREQ (NNRR) and used concept of requested zone and expected Zone to limit area of route discovery. The scheme is improved by means of the efficient update of source and the destination node position to a wider range out of the transmission range of itself. This scheme reduces the routing overhead and improves network throughput.**

***Keywords*—** AODV, Hello Messaging, Network Overhead, NNRR, Routing.

INTRODUCTION

MANET [2], is a wireless infrastructure-less network having mobile nodes and the communication between these nodes can be achieved by using multi-hop wireless links. Here each node will act as a router and can forward data packets to the other nodes. Mobile ad-hoc networks operate without any centralized base station and uses multi-hop relaying. No fixed infrastructures are required to allow such communications; rather all nodes cooperate in the task of routing packets to destination nodes. This is required since each node of the network is able to communicate only with those nodes located within its transmission radius R, while a source node S and a destination node D of the MANET can be located at distance much higher than R. When S wants to send a packet to D, the packets have to cross many intermediate nodes and for this reason, MANETs belong to the class of the multi-hop wireless networks. The main advantage of MANET is its instant deployment.

Routing is an essential operation in ad hoc networks, which defines the process of directing the data packets from a source node to the destination. A number of routing protocols have been suggested for use in MANETs. Ad hoc On demand Distance Vector Routing (AODV) [3], Dynamic Source Routing (DSR), Location Aided Routing (LAR) [4] in which nodes search for or maintain a route only when route is needed, and periodic (proactive) protocols such as Destination Sequence Distance Vector (DSDV) [5], Distributed Bellman Ford [6] in which nodes periodically exchange routing information and then can always know a current route to each destination. Several protocols are also there using both reactive and proactive mechanism such as Zone Resolution Protocol (ZRP) [7], Cluster Based Routing Protocol (CBRP) [8]. The basic idea of on-demand routing protocols, is that a source node sends a route request and makes routing decision based on received route reply, which may be sent by destination or intermediate nodes. On-demand routing has several advantages, such as simplicity, correctness and flexibility.

MANET routing protocol, AODV [11], is used in which a new path is discovered through RREQ and RREP packet exchanges. Route maintenance of active routes in AODV [11] is done by continuously monitoring the link status of next hops. Periodic HELLO messaging to the neighbor node is used to check whether the link exists. When a link failure is noticed an RERR message is sent upstream to source node. By re-initiating the route discovery, source finds an alternate route to the unreachable nodes.

A Hello messaging scheme for neighbor discovery in MANETs [10] is an improvement in Adaptive Hello Messaging Scheme for Neighbor Discovery in On-Demand MANET Routing Protocols [13], which effectively reduce the unnecessary Hello messages. This suppressing of the unnecessary hello messaging is done by calculating the event interval. Here also included a method of detecting the link failure before its occurrence. The scheme suppresses unnecessary Hello messaging and reduces the energy consumption without any additional delay.

In conventional on-demand routing protocols [9], a node discovers routes to a particular destination, by broadcasting a RREQ. Upon receiving the RREQ, the node checks whether or not the packet has been previously received. In case of packet has been received previously the node will drop the packet, otherwise the node will checks whether it has a route to the destination, if yes, the node will send back RREP to the source node; otherwise the node will rebroadcast the RREQ to its immediate neighbors until the destination is found. This method of route discovery is referred as blind flooding. Every mobile node rebroadcasts one copy of received RREQ, so the maximum number of rebroadcasts is equal to N – 2, where N is the number of nodes in the network. This can potentially lead to excessive redundant retransmissions therefore high channel contention and causing excessive packet collisions in dense networks. Such a phenomenon is refried to as broadcast storm problem [16], which significantly increases network communication overhead and end-to-end delay [16, 17]. To reduce the impact of blind flooding, a number of broadcasting techniques have been suggested in [16, 17, 18].

Many approaches are proposed to improve flooding performances by reducing the number of redundant messages. In Nominated Neighbors to Rebroadcast the RREQ nominated neighbors are allowed to rebroadcast RREQ packets from different zones. According to this scheme the requested zone and expected zones are calculated on the bases of GPS information shared in between nodes. With the help of expected zone we can limit the area of route discovery.

MOTIVATION

The broadcast protocols are categorized into four families: Simple Flooding, Probability Based Methods, Area Based Methods and Neighbor Knowledge Methods [15].

Simple Flooding: Simple Flooding requires each node to rebroadcast all the packets. The algorithm starts with a source node broadcasting a packet to all its neighbors. Each of those neighbors in turn rebroadcast the packet exactly one time and this continues until all reachable network nodes have received the packet.

Probability Based Methods: The Probability Based Methods use some basic understanding of the network topology to assign a probability to a node to rebroadcast. Some probabilistic based methods are:

Probabilistic Scheme**:** The Probabilistic scheme is similar to flooding, except that nodes only rebroadcast with a predetermined probability. In dense networks multiple nodes share similar transmission coverage's. Thus, randomly having some nodes do not rebroadcast saves node and network resources without harming delivery effectiveness. In sparse networks, there is much less shared coverage; thus, nodes won't receive all the broadcast packets with the probabilistic scheme unless the probability parameter is high.

Counter-Based Scheme**:** In the counter-based scheme, upon receiving a previously unseen broadcast message, the mobile node initializes a counter with a value of one and set a random defer time. During this deferring time; the counter is incremented by one for each redundant message received. If the counter is less than a predetermined threshold, when the deferring time expires, the message will be relayed. Otherwise, it is simply discarded.

Area Based Methods: The Area Based Methods assume nodes have common transmission distances; a node will rebroadcast only if the rebroadcast will reach sufficient additional coverage area. Suppose a node receives a packet from a sender that is located only one meter away. If the receiving node rebroadcasts, the additional area covered by the retransmission is quite low. On the other extreme, if a node is located at the boundary of the sender node's transmission distance, then a rebroadcast would reach significant additional area, 61% to be precise.

Neighbor Knowledge Methods: The Neighbor Knowledge Methods maintain state on their neighborhood, via Hello packets, which is used in the decision to rebroadcast. One of the neighbor knowledge methods is flooding with self pruning.

Flooding with Self Pruning: This is a simple method. This protocol requires that each node have knowledge of its 1-hop neighbors, which is obtained via periodic Hello packets. A node includes its list of known neighbors in the header of each broadcast packet. A node receiving a broadcast packet compares its neighbor list to the sender's neighbor list. If the receiving node would not reach any additional nodes, it will stop from rebroadcasting; otherwise the node rebroadcasts the packet.

EFPA [14], the author proposed an efficient flooding algorithm, which generates a small number of packet transmissions during a short time. EFPA [14] allocates a priority of packet transmission or a waiting time to every node considering the distance from a sender node and the direction of packet transmission, so every node in a network can receive packets rapidly.

SYSTEM ENVIORNMENT

The aim is to improve the network performance by eliminating the redundant retransmission and restricting the area of route discovery. This can be achieved by involving a specific set of nodes in the dissemination process of the

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RREQ and use of requested zone and expected zone. The concept implemented here is to partition the radio transmission range into 4 zones and restrict the area of route discovery according to expected zone. Then one node per zone is chosen to forward the RREQ. The selection process is performed by determining the closest node to the edge of the zone to provide more coverage area. The request zone is found based on the expected zone. If the expected zone radius is small then the request zone will also be of small area. Fig1 shows the zone representation and the nominated neighbor selection.

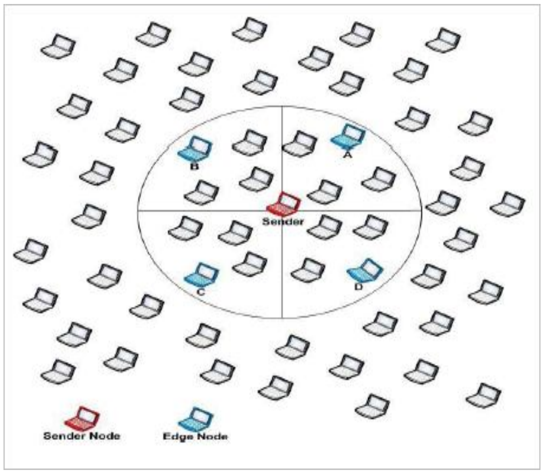

Fig 1: Divide the transmission range and locate each neighbour in the right Zone [1].

The sender attaches the address of the **N**ominated **N**eighbor to **R**ebroadcast the **R**REQ (NNRR) and information about requested zone, into the RREQ field. Any neighbors when received the RREQ it will check if the sender select it as forwarder node or not and also checks whether the node in requested zone or not, if so, it will partition its transmission range and select a new set forwarder nodes and attach them into the RREQ and rebroadcast the RREQ, otherwise it will discard the RREQ. Every node shares its position information with its direct neighbor through the HELLO message mechanism [12].

To locate each neighbor in the right zone the following equation is used:
S: Sender node; A, B, C, D: Nominated neighbor nodes.
if: $S_x \leq A_x$ and $S_y \leq A_y$ (1)
Then we can locate node A inside Zone 1 of node S.
Else if: $S_x > B_x$ and $S_y \leq B_y$ (2)
Then we can locate node B inside Zone 2 of node S.
Elseif: $S_x \geq C_x$ and $S_y > C_y$ (3)
Then we can say node c inside Zone 3 of node S.
Else: $S_x < D_x$ and $S_y < D_y$ (4)
Then we can say node D inside Zone 4 of node S.

After locating each neighbor in the right zone, and then we the distance from the sender node to each neighbor is calculated according to bellow equation:

$$\text{Distance}(S; N) = ((S_X - N_X) + (S_Y - N_Y))^{1/2} \qquad (5)$$

According to equation 5, node S is able to know the distance from each neighbour. So now node S locates each neighbour in the right zone from its perspective in addition to the distance from each neighbour. To choose the nominated neighbour in each zone, node S will choose the farther node in each zone.The sender then attaches the four nominated neighbours into NNRR as well as the request zone coordinates inside the RREQ field. The modified RREQ is shown in fig 2.

Type	J	R	G	D	U	Reserved	Hop Count
RREQ ID							
Destination IP Address							
Destination Sequence Number							
Originator IP Address							
Originator Sequence Number							
NNRR IP Address							
Request zone co-ordinates							

Fig 2: Modified RREQ [1].

Expected Zone:
The Expected Zone is the region where source node S expects that the destination node D may contain at some time t. If S doesn't have the previous knowledge of the location of D, S will assume that the entire region is the expected zone. The size of expected zone can be reduced if node has more knowledge about the mobility of a destination D.

Request Zone:
Node S defines a request zone for the route request. Node forwards a route request only then it belongs to the request zone it does not forward a route request to its neighbor if it is outside of the request zone. The request zone includes expected zone in addition to other surrounding zone around the request zone.

- If a route is not discovered within the timeout period, source initiates a new route discovery with expanded request zone – all paths from S to D include nodes that are outside the request zone.
- The probability of finding route can increase as size of request zone increases.

The request zone is rectangular in shape. Assume S knows that the node D was at location (X_d, Y_d) at time t_0. Assume S knows the average speed v with which D can move. S defines the expected zone at time t_1 with radius $R = v\,(t_1 - t_0)$

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cantered at location (X_d,Y_d). Fig 3 shows the requested zone and expected zone calculation.

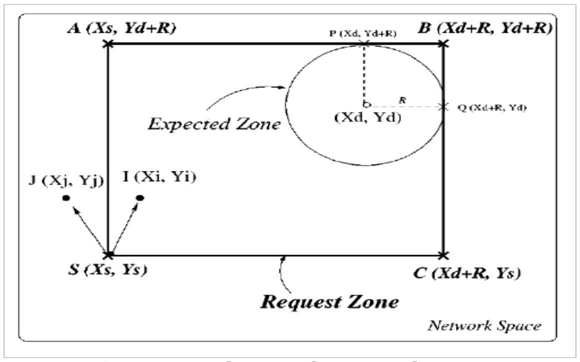

Fig 3: Expected zone and Requested zone with co-ordinates [1].

Each node finds its own position using the GPS (Global Positioning System). This location information is shared among its direct neighbors using the hello messaging mechanism. At the end, node S will send the RREQ to the neighbours. This RREQ now contains four nominated neighbours (A, B, C and D) as well as the requested zone coordinates. On the reception of RREQ, each node checks NNRR field inside RREQ and the decision of rebroadcast is taken based on the inclusion of its network address in the list. If the node finds its address inside this field that means rebroadcast the RREQ, otherwise discard it. Nodes A, B, C and D when receive the RREQ, they check NNRR field and since they find themselves inside the RREQ therefore they do the same as node S and rebroadcast the RREQ. Flowchart of processing a new RREQ packet on the sender side and receiver side is as shown in fig 4.

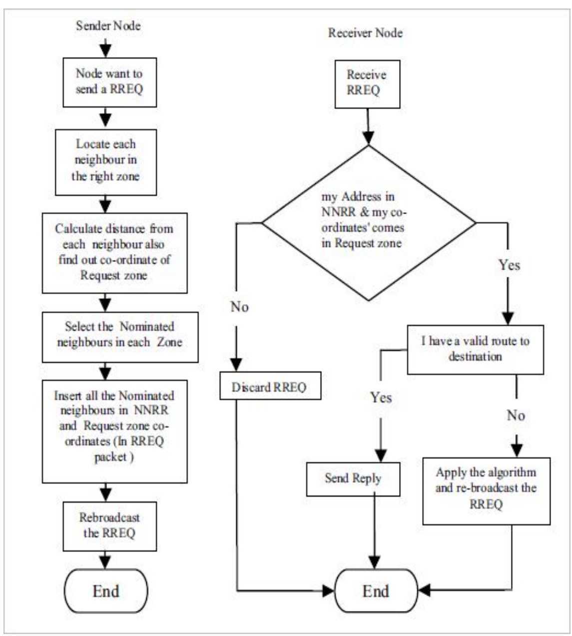

Fig 4: Flowchart of processing a new RREQ packet on the Sender side and Receiver side [1].

In MANETs all the nodes move randomly with high mobility, the farthest neighbors may move out of the communication range with a high probability. Also, due to the collisions, interference and decrease of the channel capacity with high distance between the sender and receiver; some farthest neighbors in the nominated list may fail to receive the broadcast RREQ successfully. We deal with these problems by mechanisms in which the nominated nodes are nominated based on their distance from the source node. A source node can select only a nominated node among the neighbors if the distance between them is less than 85% of the source transmission range.

Some of the drawbacks for this scheme are:

a) If the destination never came close to the source at any time, source would be totally blind about destination position. So it will fail to apply equations for finding the radius to create the expected zone.

b) Position updating takes place only when nodes become direct neighbors, because it use hello messaging scheme to update position which has scope only to neighbors. As the number of nodes increases or area widens the chance of direct meeting will become less and less likely. The positions will be hours old and the radius of circle will increase tremendously making algorithm useless and also cause high overhead.

c) If the destination node made a change of course in between, it will fall entirely out of the calculated circle making it unable to reach by RREQ. This causes data loss.

The scheme is improved by means of the efficient update of source and the destination node position to a wider range out of the transmission range of itself. To make the position update efficient we proposes 2 mechanisms:

1. Update the position of the source node through RREQ: The source while creating RREQ adds its current position in one of the RREQ fields. Because the RREQ is broadcasted to multi-hop distances, has more scope than hello. So new positions will reach beyond the transmission range. All nodes will send and receive data so positions are frequently updated. Hello updating is also there. The modified RREQ packet format is shown in fig 5.

Type	J	R	G	D	U	Reserved	Hop Count
RREQ ID							
Destination IP Address							
Destination Sequence Number							
Originator IP Address							
Originator Sequence Number							
NNRR IP Address							
Request Zone Coordinates							
Node Position Coordinates							

Fig 5: RREQ for position updating.

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2. Update the position of the destination node through RREP: The destination while creating RREP adds its current position in one of the RREP fields. This RREP is unicasted to the source node. So in the entire route length all nodes will get new position of the destination.

Thus, in one successful data transmission positions of two nodes are updated throughout the network. This will increase the accuracy of the algorithm, making it able to meet the promised advantages of the low routing overhead.

PERFORMANCE EVALUATION

In order to evaluate the performance of our proposed protocol, we compare the RREQ for Efficient Flooding in Mobile Ad hoc Network (NNRR) [1], and proposed protocol. We simulate the proposed mechanism by creating the simulation in java. The AODV protocol is also implemented here. The simulation environment, performance metrics and results are discussed in this section.

Some of the parameters used for performance evaluation are:

1. Total Throughput: The total number of data bits successfully transmitted in the network per second.
2. Total Overhead: The number of control packets transmitted in the network.
3. Packet Delivery Ratio: The ratio of the data packets succeed to deliver at the destinations to those generated by the sources.
4. Data Drop: This includes all deleted packets in the network.

The performance evaluation results are:

1. Total Throughput:

   Throughput is a vital metric that measures the transmission ability of a network. Fig 6 shows that the proposed scheme outperforms NNRR. The throughput improvement is due to its reduction of rebroadcasting and bounded requested zone. The fewer rebroadcasts the smaller bandwidth consumption by control messages and reduces area of route discovery. This also results in lower degree of contentions and collisions, which leads to relatively higher throughput. The proposed scheme improves the throughput more than that of the NNRR as the position updating is done beyond the transmission range.

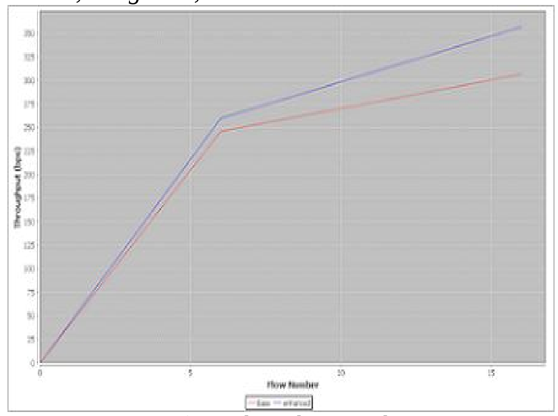

Fig 6: Throughput graph

2. Total Overhead:

   Fig 7 shows the overhead increases when the number of flows becomes high in NNRR. This is due to the reason that it sends RREQ with knowledge of which the best neighbour shall rebroadcast the RREQ. The proposed scheme performs better than NNRR since the position updating of source and the destination beyond the transmission range is done through the RREQ and RREP respectively.

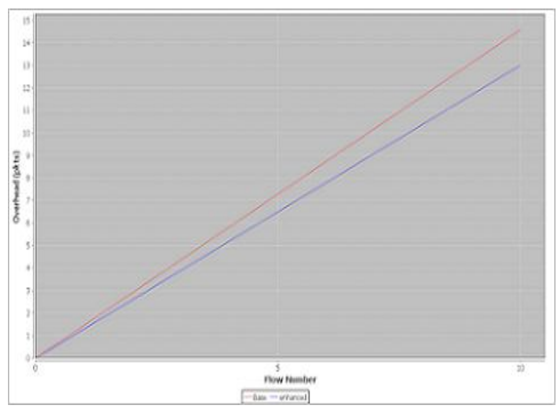

Fig 7: Total Overhead

3. Packet Delivery Ratio:

   Fig 8 shows the comparison of the packet delivery ratio and we can see that the NNRR and the proposed scheme has somewhat similar packet delivery ratio but the proposed scheme has more packet delivery ratio than NNRR. This is because the position updating is done beyond the transmission range. The proposed and the NNRR scheme is able to maintain the level of stability, because only the sender selected nodes will forward the RREQ.

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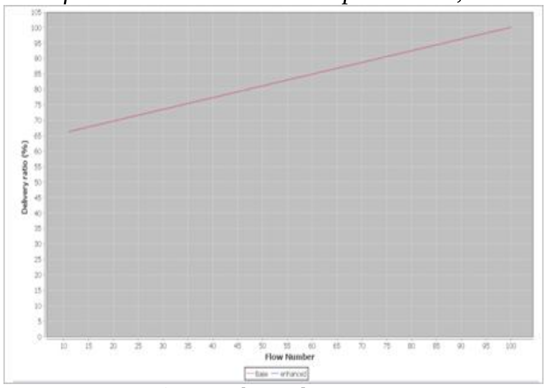

Fig 8: Packet Delivery Ratio

4. Data Drop:

Fig 9 shows that the proposed scheme has lower data drop than NNRR. In NNRR case, the data drop is reduced by reducing the area of route discovery by the concept of expected and requested zones. The proposed scheme has less data drop than NNRR since the position updating is done beyond the transmission range.

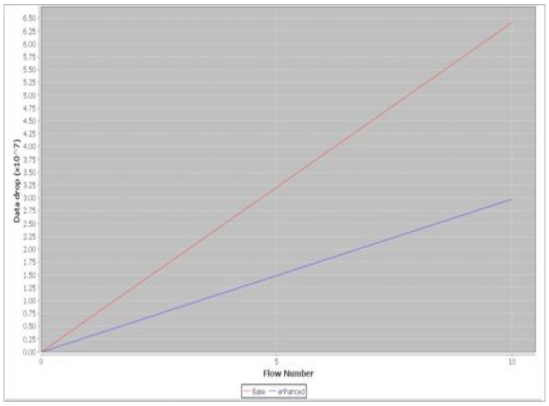

Fig 9: Data Drop

CONCLUSION

The NNRR has been proposed to improve the flooding process for MANET. Knowing the geographical position of the mobile nodes can assist the protocol to reduce the number of retransmissions and can reduce area of route discovery, therefore enhancing the protocol performance. NNRR protocol selects four neighbors as nominated to rebroadcast the RREQ in case there aren't available route on those nodes rather than all the neighbors rebroadcast the RREQ and use the concept of Expected and Requested zone of LAR routing. The scheme is improved by means of the efficient update of source and the destination node position to a wider range out of the transmission range of itself. This is done by means of 2 mechanisms: update the position of the source node through RREQ and update the position of the destination node through RREP. Thus, in one successful data transmission positions of two nodes are updated throughout the network. This will increase the accuracy of the algorithm, making it able to meet the promised advantages of the low routing overhead. We succeed to maintain the level of connectivity among the network and at the same time reduce the overhead.

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