A NOVEL APPROACH FOR MINIMIZING CONGESTION AND ENHANCING NETWORK LIFETIME IN MANETs

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ABSTRACT:
Most existing routing protocols follow the shortest route for routing between sources to destination with minimum hop count. However the delay between two communicating nodes, energy consumption of nodes and network lifetime are never considered through this shortest route. It makes difficult to select a long lasting route between the nodes in network. To achieve optimal path, we have proposed a new Modified AODV (M_AODV), which selects the route according to above three performance metrics and it minimize the chance of congestion. Simulation results shows that M_AODV has better performance comparing with AODV routing protocol in terms of network lifetime, packet delivery ratio, throughput, Packet loss and Routing Delay during simulation.

Keywords: MANETs, Congestion, Residual Energy, Routing Delay, Throughput, Packet Loss, Network Lifetime, Mobile Connections

[1] INTRODUCTION

Mobile ad hoc networks (MANETs) [1] are numerous numbers of wireless mobile devices, that don't need any fixed infrastructure support to converse with each other. It has no central authority because this type of network is self maintained and self-configured. Each node performs like a host and also a router as well. Dynamic nature based topology, inadequate bandwidth; limited battery power, CPU resources and conversation in multi-hop are the uniqueness that keep special challenges in the design of routing protocol.

A various number of routing protocols [2][3] have been introduced by researchers for MANETs. These protocols have been categorized into three types on the basis of route discovery process i.e. Proactive, Reactive Protocols and Hybrid Routing Protocols. Proactive routing protocols such as DSDV [5] always contain the tables which maintain consistent, up-to-date routing information from each node to every other node in the network. No. of routing tables are used to keep the routing information and if any information change then according to changes routing tables are updated and maintain consistency in network. The reactive protocols such as DSR [4] and AODV, establish path between source nodes to destination nodes only while there is a need to send out data packets via spreading out control packets among the neighbor nodes. Hybrid routing algorithm like ZRP combines the two previous techniques (proactive and reactive) in an attempt to bring together...
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the advantages of the two approaches. Such algorithms are designed to increase scalability by allowing
the nodes closest to each other to connect and form a number of groups and then assigning the group
nodes different functionalities, both inside and outside the group, to reduce the route discovery
overhead. For optimal path many of them choose minimum hop count approach and this is shown by
research that we cannot find stable path only by using minimum hop metrics. Because minimum hop
count method does not minimize the route breakage during the data transmission, it takes some time
in sensing link failure and after that route recovery process is initiated. All these processes consume
lot of network bandwidth and battery power. Selecting routes that go on long time decreases the
chances of route failure and route re-finding process, which considerably get better the network
performance of ad-hoc networks.

The primary applications of such MANET networks have been in disaster relief activities,
military purpose, conferencing and environment sensing. It uses radio frequency technology that
allows more mobility to the devices, because there is absence of cable. MANET networks are
installed easily in such condition where it is require fast set up like in battlefield or in accident areas
for emergency purpose. MANET supported applications spread out the packets among the nodes in
his transmission range for communication. A set of routing rules or protocols are needed in order to
communicate with non-neighboring nodes via multi hop. Therefore we need efficient and such a
stable path which could provide longer transmission that is necessary for the application where
continuous data forwarding is required such as audio or video communication. Mobile ad hoc
networks have mobile nodes which are densely or lightly deployed in an unorganized pattern. The
topology of MANET network continuously changes because of node random mobility and this leads
to frequent link disconnection between communicating nodes.

The mean of this algorithm is to put forward a novel routing protocol M_AODV that considers
energy consumption, node remaining energy and delay during route discovery for reliable data
communication across the network. It decreases congestion among nodes and increases the network
lifetime.

The paper is classified as follows. In section I, introduction on MANET routing protocols and
their classifications are presented. Section II, describes the background and related work on energy
consumption and delay based routing. Section III, presents the explanation of the proposed algorithm
Modified AODV in detail. Section IV, simulation graphs and results are shown. Last conclusion and
future works for proposed Modified AODV are given in section V.

[2] BACKGROUND AND RELATED WORK

In MANET, to find an optimal path between sources to destination is one of the most important
and challenging issue. We can define an optimal route in MANET as a route which always offers
connectivity between source to destination even in high mobility network and this route does not get
disconnected for a certain period of time during data transmission. In order to find the optimal route,
a number of approaches have been proposed by the researchers which are based on congestion based
parameter (delay) and energy aware based parameter i.e. node remaining energy, energy consumption
and network lifetime. The Ad-hoc On-Demand Distance Vector (AODV) [6][7] enables dynamic,
self-starting, multi hop routing between participating mobile nodes that want to establish and
maintain an ad hoc network. AODV allows mobile nodes so that nodes can obtain routes quickly for new destinations, and those nodes which are not in active communication. AODV does not allow route maintenance of those nodes. If any change in topology and any link breakage in network then AODV always respond. If two routes to destination are chosen so AODV provide facility to choose the route with greatest sequence number. This energy imbalance affects the reliability of the system.

When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a path discovery process to locate the other node. It broadcasts a route request (RREQ) packet to its neighbors, which then forward the request to their neighbors, and so on, until either the destination or an intermediate node with a “fresh enough” route to the destination is located. Figure 1 illustrates the propagation of the broadcast RREQs across the network. AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number, as well as a broadcast ID. The broadcast ID is incremented for every RREQ the node initiates, and together with the node’s IP address, uniquely identifies an RREQ. Along with its own sequence number and the broadcast ID, the source node includes in the RREQ the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ. During the process of forwarding the RREQ, intermediate nodes record in their route tables the address of the neighbor from which the first copy of the broadcast packet is received, thereby establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. Once the RREQ reaches the destination or an intermediate node with a fresh enough route, the destination/intermediate node responds by unicasting a route reply (RREP) packet back to the neighbors from which it first received the RREQ.

![Figure 1: Propagation of RREQ and RREP](image_url)

In EM-AODV [8], Route Selection is based on residual energy factor. It is a reactive routing protocol which combines two mechanisms used in the basic AODV protocol. Rapid change of

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topology causes that the route reply could not arrive to the source node, i.e. after a source node sends several route request messages, the node obtains a reply message, and this increases in power consumption. To avoid these problems, here first mechanism proposed Multipath AODV which tries multiple route replies. Multi-path AODV (M-AODV) uses absolutely same procedure of RREQ of AODV to deliver route reply message to source node. This mechanism can reply from destination to source if there is at least one path to source node. The second mechanism proposes a new adaptive approach called Energy AODV which seeks to incorporate the metric "residual energy" in the process route selection, indeed the residual energy of mobile nodes was considered when making routing decisions. In this approach, firstly calculated the energy consumption, then estimated residual energy and after that expected residual lifetime. Then after route establishment cost have been calculated.

In RESA-AODV [9], signal strength, delay parameters have been defined. Delay is mainly used to avoid congested path. In this protocol, route selection is based on these parameters. Optimal path is found only when these parameters satisfied particular threshold values.

There are some protocols [10][11][12][13] which consider both congestion based (i.e. delay) and energy based metric (residual energy) during route discovery. But we did not find any protocol that consider performance metrics like energy consumption, node remaining energy and delay all together during route discovery. Energy consumption mainly used for high load and delay is for avoid congestion among nodes. So we propose a approach in which energy consumption, node remaining energy and delay all together to find optimal path for route discovery. The main goal of this paper is to enhance the network lifetime and decrease the congestion among nodes.

[3] PROPOSED WORK

Modified AODV has been introduced and rule for reliable route selection during the route discovery process has also been proposed. In MANET node mobility and fast energy depletion makes a challenging issue in obtaining a reliable optimal route for data transfer between sources to destination. For this intention to find an optimal route between sources to destination a novel routing mechanism has been proposed in this paper and simulation results show that route created by this mechanism has more stability. Many researchers [13] have shown that delay between two communicating nodes and their node energy level play an important role in link stability. Link can be break either if this delay becomes large i.e. beyond the communication range or if node goes out of order because of energy depletion. So in our proposed work we focus to add only those nodes in path whose delay and energy consumption is less that satisfied specified threshold value. We also consider other parameter such as node remaining energy and path lifetime.

3.1 Node Remaining Energy Calculation:

Energy model is one of the available energy models in NS2. This is attached to our scenario file during simulation time. Energy model is used for calculating the remaining energy and total energy consumption. We first initialize the nodes energy with some initial value then each node makes a call to energy model to calculate the remaining energy. If a particular nodes remaining energy value is less than the threshold value, then the path related to that node is not selected to transfer data.
3.2 Node Network Lifetime Calculation:

In our mechanism, we do not only consider the current energy level value of a node, we observe also the speed of energy consumption at each constant time \( T_{update} \). For each node, we follow the following formula to compute energy speed consumption.

\[
E_{\text{energy_{consum}(j)}} = \frac{E_{\text{energy_{rest}(j-1)}} - E_{\text{energy_{rest}(j)}}}{T_{update}}
\]

Where \( E_{\text{energy_{rest}(j)}} \) is the estimated residual energy computed at time j. Then, we can estimate the expected residual life time \( T_{\text{lifetime}(j)} \) in each node considering the energy speed consumption \( E_{\text{energy_{consum}(j)}} \) and the estimated residual energy \( E_{\text{energy_{rest}(j)}} \) values computed at each time interval j as follow:

\[
T_{\text{lifetime}(j)} = \frac{E_{\text{energy_{rest}(j)}}}{E_{\text{energy_{consum}(j)}}}
\]

3.3 Routing Delay Measurement:

Routing delay metric is mainly used to avoid congested path. So to avoid congested path we calculate delay between communicating nodes. At each intermediate nodes, two timers are used which calculate sending time and receiving time of packet. When packet is arrived at the node, delay is calculated by subtracting receiving time from sending time. This calculated value is compared with threshold value, if it less than or equal to threshold value then it process the request packet otherwise it drops the request packet.

3.4 Route Discovery Process based on Proposed Modified AODV:

In Proposed Modified AODV, optimal reliable route is selected during route discovery before data transmission. When the route is needed, the source sends the RREQ packet to his entire neighbors, and then it selects the route on the basis energy consumption and path lifetime and routing delay. Firstly when RREQ reaches at intermediate nodes from source nodes then here check congestion. If congestion occurs then here introduce delay parameter for removing congestion among nodes. For this delay, set maximum value of delay. According to this threshold value, RREQ further proceed. When RREQ received by destination node, it checks route reply based on path lifetime of nodes. Here it checks route latency is equal to specified threshold value, if yes then reply to route which having highest path lifetime among all. Otherwise it buffers the path for temporary storage.

3.5 Pseudo Code of Modified AODV:

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```plaintext
if ( path exists for destination ) { // Source Node
    transmit data
} else {
    // Initiate route discovery
    Route discovery process // AODV Route Request Process
    send RREQ(); // Source Sending Request
}

Packet reception routine
If ( packet type is RREQ ) {
    If ( I am Destination && route_latency == 0.1 ) { // Destination Node Routine
        Send RREP() = MAX(rq_pathlife, r_buffer) // Routing Decision at Destination Node
    } else {
        r_buffer = rq_pathlife // buffer the path in temp file called r_buffer
    }
    If ( i am an intermediate node ) { // Intermediate Node Routine
        If ( i have a fresh route to destination ) {
            If ( Delay <= Dmax ) { // Routing Decision at Intermediate Node
                send RREP() // Send Reply to Source
            } else {
                discard the RREQ
            }
        } else {
            Send RREQ to other neighbour node
            rq_pathlife += node_lifetime // buffer node_lifetime in rq_pathlife field of request packet
        }
    } else {
        discard the RREQ
    }
}
```
In proposed Modified AODV, whenever an intermediate node gets route request from source or its neighbor node, it selects routes based on Routing delay. Here it checks delay is lesser than or equal to threshold value, if yes then it process route request. Otherwise discard route request.

3.7 Route Reply mechanism at Destination Node:

In proposed Modified AODV, whenever route request received by destination node, then it selects routes based on Path Lifetime. Here it checks route latency is equal to specified threshold value, if yes then reply to route which having highest path lifetime among all. Otherwise it buffers the path for temporary storage.
[4] SIMULATION RESULTS

The simulation parameters have been shown in Table 1.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topology area</td>
<td>1000m * 1000m</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>50</td>
</tr>
<tr>
<td>Mobility model</td>
<td>Random Waypoint</td>
</tr>
<tr>
<td>MAC layer</td>
<td>IEEE 802.11 DCF</td>
</tr>
<tr>
<td>Propagation model</td>
<td>Two Ray Ground</td>
</tr>
<tr>
<td>Antenna type</td>
<td>Omni directional</td>
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<tr>
<td>Transmission range (m)</td>
<td>250</td>
</tr>
<tr>
<td>Simulation Time (s)</td>
<td>200</td>
</tr>
<tr>
<td>Traffic Type</td>
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</tr>
<tr>
<td>Packet size (B)</td>
<td>512</td>
</tr>
<tr>
<td>Traffic rate (packets/s)</td>
<td>4</td>
</tr>
<tr>
<td>Maximum node speed (m/s)</td>
<td>5 – 30</td>
</tr>
<tr>
<td>Maximum Dmax (s)</td>
<td>0.1</td>
</tr>
<tr>
<td>Rate (packet/sec)</td>
<td>4-20</td>
</tr>
<tr>
<td>Max. Mobile Connections</td>
<td>5 – 25</td>
</tr>
</tbody>
</table>

Table 1: Simulation Parameters

Here, we designed and implemented our proposed work using Network Simulator-2 [15] to test the performance of M_AODV and existing AODV Routing protocol.

4.1 Performance Metrics: These metrics are used for result analysis. Some of them are listed below.

- **Packet Delivery Ratio (PDR):** The ratio of data packets received at destination side and total number of data packets generated by the source node is called packet delivery ratio.
- **Throughput:** Number of packet received at destination side in unit time is called throughput.
- **End to End Delay:** This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.
- **Packet Loss:** The Percentage of packets that are dropped from the queue due to overflow (congestion) to the total arrival in the queue is a packet loss.
- **Network Lifetime:** It is defined as the time when a node runs out of its own battery power for the first time.

4.2 Simulation Results:

The comparative analysis of purposed M_AODV and existing AODV has been done under varying simulation environment using NS-2 simulator. Simulation is performed for 50 nodes where data rate vary from 4-20 (packet/sec). Simulation is also performed in heavy load environment where number of mobile connection changes from 5-25. Other simulation parameters are given in Table 1. The results are shown to state that M_AODV outperforms than AODV. In Fig. 4, M_AODV has
better packet delivery ratio than AODV under high data rate i.e. 12-20 (packet/sec). But in case of high data rate, there is more congestion in path because of transmitting more number of packets which decreases the packet delivery ratio in AODV.

Figure 4: Packet Delivery Ratio Vs Data Rate

Figure 5: Throughput Vs Data Rate

Figure 6: Routing Delay Vs Data Rate
In AODV there is no such an admission control mechanism which avoids congested path. We introduced delay parameter in M_AODV which avoid the congested path and this result in better packet delivery performance in heavy load network. As shown in Fig. 5 and Fig. 6, M_AODV show better performance in terms of throughput and routing delay than AODV where node data rate changes from 4-20. It is because of that M_AODV considers congestion and energy based parameter like signal node remaining energy, energy consumption and delay during route discovery process. Delay avoid them congested path which improves the throughput and energy based parameter improves throughput. In Fig. 7, M_AODV have less packet loss as compared to AODV under high mobile connection (i.e. 20-25). Because there is less congestion among nodes and less energy depleted. In fig 8, as mobile connections increases, the network lifetime better in case of M_AODV. It is because of the fact that M_AODV has introduced energy parameter like node remaining energy and node energy Consumption into the process of route discovery. In our proposed work, node lifetime has been predicted by using parameter energy consumption. A node having energy consumption exhausts its energy quickly because of heavy load. So we avoid nodes having high energy consumption during route discovery.
[5] CONCLUSION

In this we have defined Modified AODV (M_AODV) and compare it with AODV. The proposed model reduces the congestion during route request mechanism and increase the network lifetime during route reply mechanism. The simulation results show significant performance improvements in terms of Packet Delivery Ratio, Throughput, Packet Loss, Routing Delay and Network lifetime during simulation. In future this technique can be used to improve other factors which cause delay in the network. Modified AODV can be used by the researchers in future for further researches. In this technique by the use of route stability, end to end delay and energy consumption can be further improved. Various parameters can be included in Modified AODV, to maintain network lifetime and throughput at varying sending rates of mobile nodes.

REFERENCES