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Improved AODV Routing Protocol for MANET

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Abstract- Efficient protocols are used to forward data packets without much packet loss. Ad hoc on Demand Distance Vector Routing Protocol (AODV) is one among the effective Reactive Routing Protocol in MANET. The main causes for link break are mobility between nodes such as node failure and node power off. Quality of Service (QoS) is one of the main issues for any network and due to bandwidth constraint and dynamic topology of mobile ad hoc networks, supporting Quality of Service (QoS) is extremely a challenging task. The objective of this paper is to enhance the network performance of AODV, when frequent link failure in network due to mobility of the nodes in the network.
This paper proposed a new protocol Enhanced AODV (E-AODV) which is a modified version of AODV with enhanced packet delivery ratio and minimized end to end delay.
Index Terms- Ad Hoc Network, Routing Protocol, AODV, Packet delivery ratio, end to end delay.

I. INTRODUCTION

Mobile Ad hoc Network (MANET) [1,2] is a wireless i.e., access control and security. Routing in MANET means the directed flow of data from source to destination maximizing the network performance.
The characteristics of these networks are summarized as follows:

- Communication via wireless Network.
- No centralized controller and infrastructure.
- Dynamic network topology.
- Frequent routing updates.
- Nodes can perform the roles of both hosts and routers.
- Intrinsic mutual trust.
- Some of the applications of MANETs are
- Disaster relief operations.
- Defense Development.
- Urgent Business meetings.
- Mine site operations.

Network Simulator (NS-2) is an event driven, object oriented network simulating tool, very much used by the researchers, professors and students. Simulation is the process of creating a model with its behavior. There are numerous network simulating tools available such as NS-2, GloMoSim, OPNET, QualNet, etc. NS-2 is the outperforms among all the other tools. The Routing protocols of MANET such as DSDV, DSR, AODV is implemented using NS-2 and it's available as free open source programs. In this paper, AODV protocol is considered and its network performance is enhanced by E-AODV.

The rest of the paper is organized as follows: Section II gives an overview of Routing Protocols of MANET and Section III describes the Reactive Routing Protocol AODV, Section IV discusses the proposed topology used for E-AODV, Section V describes NS-2 implementation of E-AODV, section VI discusses about simulation results and analysis and final network of collection of independent mobile nodes that Section VII discusses about conclusion derived from the can communicate to each other via radio waves. The mobile nodes that are in radio range of each other can directly communicate, whereas others needs the aid of intermediate nodes to route their packets. These networks are fully distributed, and can work at any place without the help of any infrastructure. This property makes these networks highly flexible and robust. The dynamic change in MANET topology [3, 4] makes routing as a challenging task, as the existing path is rendered inefficient and infeasible. The major issues for mobile ad hoc networks are medium access control (MAC), routing, security and quality of service provisioning. The paper addresses the routing problem in a mobile ad hoc network without considering the other issues, Implemented results.

II. ROUTING PROTOCOLS FOR MANET

Routing protocols in ad hoc networks vary depending on the type of the network [3, 4, 5]. Typically, ad hoc network routing protocols are classified into three major categories based on the routing information updated mechanism. They are proactive (table driven routing Protocols), reactive (on-demand routing protocols) and hybrid routing protocols. In addition, protocols can also be classified according to the utilization of specific resources, such as power aware routing protocol and load aware routing protocols and so on.

A. Proactive Routing Protocols

Routes to all destinations are maintained by sending periodical control messages. There is unnecessary bandwidth wastage for sending control packets. Proactive routing protocols are not suitable for larger networks, as it needs to maintain route Information every node's routing table. This causes more overhead leads to consumption of more bandwidth. Ex: DSDV [10, 11].

B. Reactive Routing Protocols

Routes are found when there is a need (on demand). Hence, it reduces the routing overhead. It does not need to search for and maintain the routes on which there is no route request. Reactive routing protocols are very pleasing in the resource-limited environment. However the source node should wait until a route to the destination is discovered. This approach is best suitable when the network is static and traffic is very light. Ex: DSR, AODV. [15, 16].

C. Hybrid Routing

The Ad Hoc network can use the hybrid routing protocols that have the advantage of both proactive and reactive routing protocols to balance the delay and control overhead (in terms of control packages). The difficulty of all hybrid routing protocols is the complexity of organizing the network according to network parameters. The common disadvantage of hybrid routing protocols is that the nodes that have high level topological information maintains more routing information, which leads to more memory and power consumption.

D. ANALYSIS

There are two approaches to evaluate routing protocols:

- Network Environment Parameters like network size, connectivity, mobility, link capacity etc.
- General Performance Metrics of Routing Protocols like

message delivery ratio, control overhead, hop count, end to end delay, etc. [13,14]
In this paper packet delivery ratio and average end to end delay performance parameters are considered.

III. AODV PROTOCOL

AODV protocol allows mobile nodes to quickly obtain routes for new destinations, and it does not require nodes to maintain routes to destinations that are not in active communication. Also, AODV routing permits mobile nodes to respond link breakages and changes in network topology in a timely manner. The main objectives of the protocol is quickly and dynamically adapt to changes of conditions on the network links, for example, due to mobility of nodes the AODV protocol works as a pure on-demand route acquisition system. Control messages [8, 9] used in
AODV are:

- Route Request Message (RREQ)
- Route Reply Message (RREP)
- Route Error Message (RERR)
- Route Reply Acknowledgment (RREP-ACK) Message
- HELLO Messages

A) Route discovery:

When a source node desires to send a message to some destination node, and doesn't have a valid route to the destination, it initiates a path discovery process to locate the other node. It broadcasts a route request (RREQ) control packet to its neighbors, which then forward the request to their neighbors, and so on, either the destination or an intermediate node with a new route to the destination is located. The AODV protocol utilizes destination sequence numbers to ensure that all routes contain the most recent route information. Each node maintains its own sequence number. During the forwarding process the RREQ intermediate nodes record the address of the neighbor from which the first copy of the broadcast packet is received in their route tables, thereby establishing a reverse path. Once the RREQ reaches the destination or an intermediate node with a fresh enough route, the destination or the intermediate node responds by unicasting a route reply (RREP) control packet back to the neighbor from which first received the RREQ [6,7].

B) Route Maintenance

A route discovered between a source node and destination node is maintained as long as needed by the source node. The destination node or some intermediate node moves, the node upstream of the break initiates Route Error (RERR) message to the affected active upstream neighbors/nodes. Consequently, these nodes propagate the RERR to their predecessor nodes. This process continues until the source node is reached. When RERR is received by the source node, it can either stop sending the data or reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required[9,10].

IV. PROPOSED METHODOLOGY

In this section new methodology is described to show the difference between the E-AODV and the AODV routing protocols during transmission with the following simple topology. There are four nodes in this network, and the initial topology is a grid and the method shown in Table-1. According to the scenario, at the beginning of the transmission of nodes, the two pairs are not interference with each other. At 10s, Node 2 moves towards the direction of Node 0 with a speed of 10 m/s. The distance between Node 0 and Node 2 becomes smaller and smaller, and at time 15 s, these two nodes begin to be in each others carrier sensing range, which means that these two nodes begin to share the same channel. The maximum bandwidth of the channel is around 3.64 Mbps. In AODV, where there is no QoS requirement, when Node 2 is in the interference range of Node 0,
traffics are kept on and some packets are lost during the transmission, whereas, in E-AODV, the QoS is ensured. When the promised data rate cannot

Node position	**Node 0 (50,250)**	**Node 1 (50,100)**	**Node 2 (650,250)**	**Node 3 (50,100)**
Node move-ment	Node ID	Time that node begins to move	Move-ment direction	Move-ment speed
	Node 2	10s	(550,250)	10m/s
Traffic	Direction	Duration	Traffic type	Required data rate
	Node 1-node 0	6s-18s	CBR	1.8Mbps
	Node 2-Node 3	6s-18s	CBR	2 Mbps

be satisfied any more, traffic of Node 2 is stopped at once. From this case, we could see that the E-AODV achieved the function of ensuring the QoS not only at the route discovery stage, but also during the transmission. Once the QoS is not satisfied, the traffic is stopped [8, 9].

Table 1: Scenario descriptions for proposed topology

In the topology there were 30 nodes and the simulation environment was as described in Table1. The area size is 870 m * 870 m, and 30 nodes are in this area. 50 s is added at the beginning of each simulation to stabilize the mobility model. Every simulation runs 500 s in total. Each data point in the results represents an average of ten runs with same traffic models but different randomly generated mobility scenarios. For fair comparisons, same mobility and traffic scenarios are used in both the AODV and the E-AODV routing protocols.

V. SIMULATION TRAFFIC PATTERN

The Random Waypoint model provided by NS2 is used as the mobility model [12]. The traffic type in the application layer is CBR with packet size of 512 bytes and in transport layer User Datagram Protocol (UDP) is used. The traffic pattern that used in the simulation is shown in Table 2. It is the same as what the Reference [4] uses.

Table 2: Simulation traffic pattern

Traffic flow	**Source and destination node**	**Start time(s)**	**End time(s)**
Session 1	3-4	53	174
Session 2	7-8	144	280
Session 3	4-5	290	315
Session 4	5-7	305	475
Session 5	5-6	445	483

Setting the traffic flow in such a manner aims at greater interference impact when sessions overlap. The source node and the destination node of each traffic flow are chosen by using function *cbrgen.tcl* randomly.

VI. SIMULATION RESULTS AND ANALYSIS

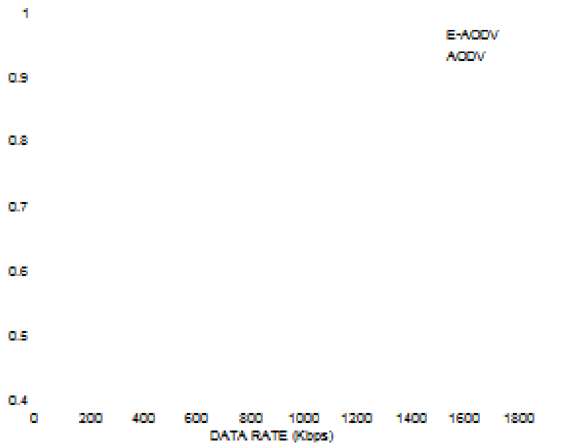
For comparing various routing protocols using UDP transport layer protocol, two performance metrics Average End to End delay and Packet Delivery Ratio are used to evaluate the performance of the AODV and the E-AODV routing protocols.

6.1 Data Rate

In this set of simulations, a group of data rates ranging from 50 kbps to 1800 kbps is applied. The mobility scenario is with a pause time of 30 seconds and the maximum node speed is 10 m/s. Three parameters defined above are calculated. The results are shown in the following figures (figure. 1 and figure.2).

6.1.1 Packet Delivery Ratio

From figure.1 we see that, either we use the E-AODV routing protocol or the AODV routing protocol, the packet delivery ratio decreases with the increase of the data rate of traffic flows.



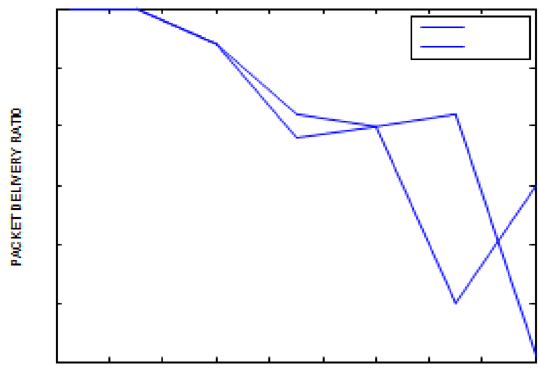
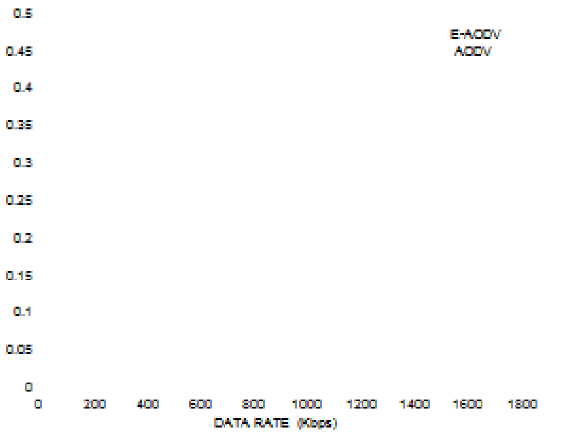


Fig. 1: Packet delivery ratio with different data rates



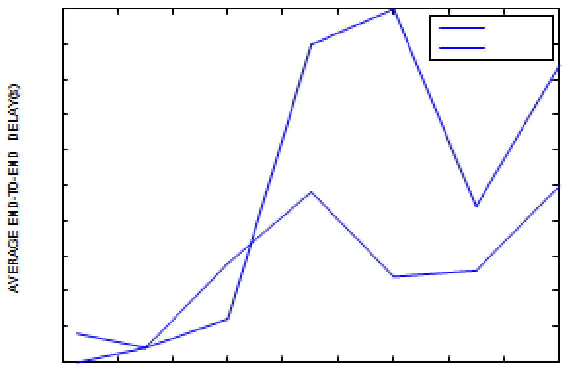


Fig. 2: Average End to End delays with different data rates

That is because the increasing data rate of flows increases traffic in the network. When the maximum throughput of nodes cannot satisfy the on-going traffic, queues at nodes begin to be full; the packets in the end of queues of nodes are dropped both at source nodes and at intermediate nodes.

The packet delivery ratio with the E-

AODV always lower than the AODV because the source node takes ore time to find a suitable route in E-AODV and during this period of time, the source which keeps on sending packets from the application layer of the node, it cause drops of packets at the end of the queue when the queue is full. Also, the traffic session can be paused anytime when the local available data rate of nodes in the path is not satisfied during the transmission in the E-AODV routing protocol. There are strict requirements in terms of data rate for traffic flow with access admission control. When data rate increases from 1500 kbps to 1800 kbps, only paths with hop count 1 or 2 can be admitted. As a result, there is more decrease in PDR with the E-AODV than in AODV when the data rate increases from 1500 kbps to 1800 kbps. It is hard to explain why the PDR increase in AODV when data rate increases from 1500 kbps to 1800 kbps .

For the above reason, the packet delivery ratio with the E-AODV routing protocol is lower than the one with the AODV routing protocol is that E-AODV routing protocol has more restrictions to the route for transmission. Actually, the packets which are not delivered and dropped at the source node because of the delay for searching for a more suitable route in the E-AODV routing protocol should be dropped. The reason is that if these packets are sent, and the route chosen is not satisfying the requirements, packets have more probability to be dropped at the intermediate node or packets may arrives at the destination node late because of the long duration of wait at the intermediate node. In other words, the E-AODV routing protocol also helps to prohibit the packets, which have more probability to be dropped during the transmission or that, arrived the destination node late, to be transmitted on the network. It helps to save the data rate as well.

6.1.2 Average end to end delay

From figure.2, it can be seen that AODV routing protocol performs better than E-AODV routing protocol when data rate is low (below 600 kbps). The E-AODV routing protocol got higher average end to end delay at the low data rate than the AODV because intermediate nodes are not allowed to perform local route repairs in case of link failures with the E-AODV routing protocol, thus, there is higher route recovery latency which results in higher end-to-end delay compared with the AODV routing protocol at low data rate.

Another reason could be that, with the E-AODV routing protocol, the number of transmitted routing packets is larger than the number of routing packets transmitted in the AODV routing protocol. In the E-AODV routing protocol, routing packets including Hello messages which have higher priority always transmitted firstly and data packets are queued nodes. With the AODV routing protocol, when the traffic is low in the network, no matter which route the traffic flow chose, the route chosen can provide enough data rate at most of the time. As a result, the end to end delay with the AODV routing protocol is not high and can be lower than the E-AODV routing protocol at low data rate. If we can take more time for simulation for each data rate comparatively accurate results can be found. For these above reasons, end to end delay in E-AODV is higher than the AODV at low data rate. The average end to end delay of the E-AODV is always below 240ms ,whereas, the end to end delay of the AODV increases badly when the data rate of each traffic flow increases from 600 kbps to 1200 kbps. It shows that networks with the E-AODV routing protocol can provide lower end to end delay for traffic flows than the AODV since the E-AODV always choose to find a route with satisfying data rate. During the transmission, the QoS of the traffic is monitored in the E-AODV routing protocol. Once the QoS is not satisfied as it promised, the traffic stopped. All in all, with the E-AODV routing protocol, the average end to end delay is low even the load on the network increases to very high which is not true for the AODV routing protocol. This performance is very significant for real time traffic transmissions.

6.2 Maximum Node Moving Speed

In the following simulations, the data rate is fixed at 1200 kbps. The maximum node moving speed is increased to see the behaviors of the AODV and the E-AODV in a fairly high mobility mode. Maximum node moving speed is changing in the range 1 m/s to 20 m/s. The results are shown in terms of average end to end delay, packet delivery ratio and normalized routing load shown in figure:3 and figure:4.

6.2.1 Packet Delivery Ratio

In figure. 3 with low max moving speed the packet delivery ratio in E-AODV is higher than the AODV but with the increase of mobility speed the performance is lower than AODV. When the maximum moving speed is up to 20 m/s, almost half of the packets are dropped in E-AODV. The reason that why more packets are dropped in E-AODV and how they are dropped has been explained in the previous part of this section.

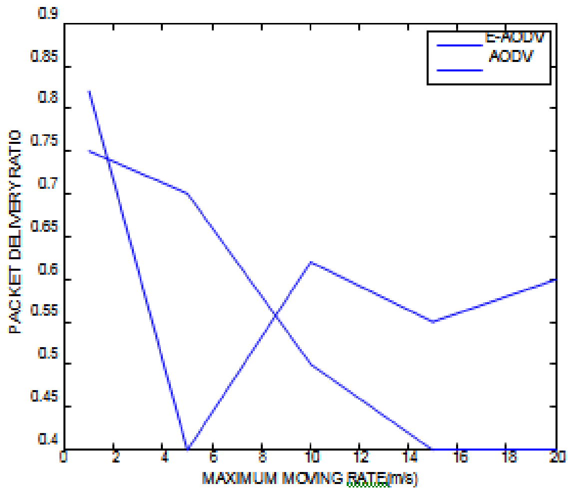


Fig. 3: Packet delivery ratio with different Max. moving speeds.

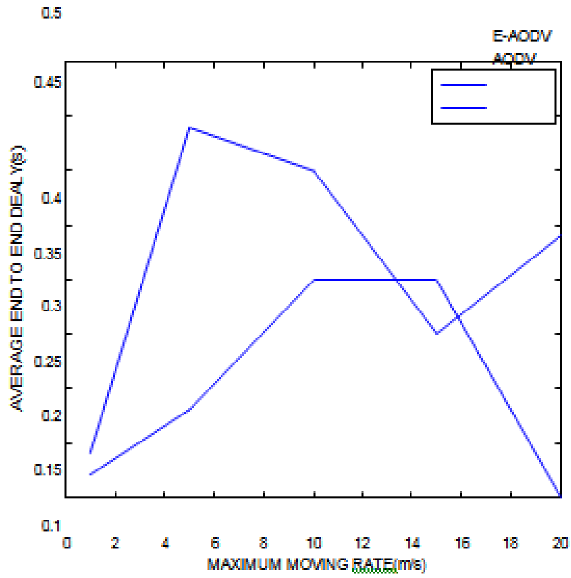


Fig. 4: Average end to end delay with different Max. moving speeds

6.2.2 Average end to end delay

As shown in figure:4, with the increase of the maximum moving speed, the average end to end delay does not increase much in E-AODV as compared with the AODV routing protocol, it means that, this protocol is quite suitable for scenarios with different moving speeds.

In comparison, with the AODV routing protocol, the end to end delay varies a lot with the increase of the maximum moving speed. It can be obviously seen that, the end to end delay in E-AODV is always much lower than the one in the AODV routing protocol. The low end to end delay of packets ensures the on time transmissions required by real time traffic transmissions.

To sum up, the E-AODV routing protocol does decrease end to end delay significantly when the data rate of traffic flows is high.

VII. CONCLUSION

In this paper, the description is given about the importance of QoS(in terms of packet delivery ratio and average end to end delay) routing in Mobile Ad-Hoc networks, challenges came across, and the approach taken. After observing the simulation and analyzing the data, it is found that packets could get less end to end delay with a QoS based routing protocol when the traffic on the network is high. This low end to end delay is meaningful for real time transmissions. When the traffic is relatively high on the network, not all the routes that are found by the AODV routing protocol have enough free data rate for sending packets ensuring the low end to end delay of each packet. As a result, the E-AODV protocol works well and shows its effects when the traffic on the network is relatively high. People who work on the area of ad hoc networks with the aim of improving QOS in terms of reduced the average end to end delay and enhanced packet delivery ratio for ad hoc networks can get benefit from this E-AODV protocol.

In the further work other additional network parameters will be considered.

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