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ADAPTIVE VELOCITY AND DISTANCE BASED ROUTING PROTOCOL FOR MANET

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ABSTRACT

A mobile ad-hoc network (MANET) is a collection of wireless mobile nodes communicating without any infrastructure. Due to the availability of small and inexpensive wireless communicating nodes, the MANET field has attracted a lot of attention from industry and academia. MANETs can be used in various applications such as mobile classrooms, battlefield communication and disaster relief applications. They may be divided into homogeneous and heterogeneous ones. Homogeneous Ad-hoc Networks nodes possess the same transmission range, but not for heterogeneous ones (i.e, networks consisting of different wireless mobile devices such as laptops, PDAs and cell phones). In AODV routing protocol, the shortest path between source and destination nodes is always selected, without collecting topology information. In this paper, we propose an improvement of AODV protocol called MDAODV (Mobility aware modified AODV). The new algorithm finds optimum path based on distance, relative velocity between two nodes and hop count. It is confirmed by simulation that this improvement has higher packet delivery ratio than standard AODV protocol.
Keywords: *Mobile Ad Hoc Networks, AODV, Distance, Transmission Range, Relative Velocity, Weight Function.*

1. INTRODUCTION

A mobile ad-hoc network (MANET) [1][2][3] is a self-configuring network of mobile routers connected by wireless links. Each node in a MANET is free to move randomly with the capability of changing its links to other nodes frequently. These networks do not require any existing infrastructure or central administration. Therefore, they are to find a path between the communication end-points of nodes. The problem is further aggravated through the node mobility. In such a network, each node acts both as a router and as a host. Due to the limited transmission range of radio interfaces, multiple hops may be used to exchange data between nodes in the network. So, that is generally used. Another limitation associated with wireless devices is the power constraint of the nodes i.e. each node has only limited battery power which should be used judiciously for the node to survive longer and to provide its services within the network. Nodes cooperate with their neighbors to route data packets to their final destinations. As intermediate nodes may fail, routes between sources and destinations need to be determined and adjusted dynamically. Routing protocols for ad-hoc networks typically include mechanisms for route discovery and route maintenance.

The most known routing protocol for MANET is the Ad-hoc On-Demand Distance Vector (AODV) [4]. This protocol is a reactive routing algorithm; the routes are created only when they are needed and every intermediate node decides where the routed packet should be forwarded next.

AODV uses periodic neighbor detection packets and maintains a routing table at each node. This routing table entry for a destination contains the following fields: a next hop node, a sequence number and a hop count. All packets destined to the destination are sent to the next hop node. The sequence number acts as a form of times tamping, and is a measure of the freshness of a route. The hop count represents the current distance to the destination node. On the contrary, Dynamic Source Routing (DSR) [8] uses the source routing in which each packet contains the complete route to the destination in its own header and each node maintains multiple routes in its cache. In case of

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less stressed situation (i.e. smaller number of nodes and lower load and/or mobility), DSR outperforms AODV in delay and throughput but when mobility and traffic increase, AODV outperforms DSR. However, DSR consistently experiences less routing overhead than AODV.

Mobility and connectivity metrics are one of the most important research topics on wireless ad-hoc networks.

Most of the routing algorithms for ad hoc networks that the nodes in the network are mobile were proposed in the literature. Yaser et al. have presented PH-MA-AODV and Agg-AODV that use mobility awareness to improve the performance of the routing algorithms with high-speed MANETs. In PH-MA-AODV, each node computes its own mobility periodically; a highly mobile node drops a route-request message to prevent itself from participating in route discovery. In Agg-AODV, each intermediate node adds its own mobility to the RREQ packet and forwards it further towards the destination; the destination chooses the path with minimum mobility [14].

In [5] the authors proposed an analysis model of link duration in multi-hop mobile networks. They gave a formulation to for the link duration between two nodes. This duration is determined by the relative speed between the two nodes and the distance during which the link is connected.

In this paper we propose a new method to find a path based on the distance and relative velocity between two nodes. The basic idea of our solution is to reduce the effect of mobility and therefore, enhance the lifetime of path routing algorithms with the help of additional information. The rest of the paper is organized as follows; in the next section, we describe in detail our solution called Mobility aware modified AODV (MDAODV). In section 3 we evaluate the performance of the proposed protocol via simulation and we conclude in section 4.

2. MOBILITY AWARE MODIFIED AODV (MDAODV)

To reduce the effect of mobility, we propose MDAODV (mobility aware AODV) protocol that is based on the AODV protocol for MANETs. MDAODV is reactive routing protocol; no permanent routes are stored in nodes. The paths, in this protocol, are chosen based on the distance, relative velocity and hop count. This allows selecting stable routes and so, reducing control message overhead. A neighbor A of node C is no stable or high mobility if node A's relative velocity with respect to node C and distance between A and C are very high.

A. Velocity And Distance Estimation

Estimation of distance and relative velocity between mobile nodes was either based on a localization system, such as the Global Positioning System (GPS) [13], or based on analyzing the characteristics of received signal [7].

In [6] the author develops a mechanism called Enhanced Transmission Power Control Mechanism (ETPCM). The proposed mechanism adapts transmission power dynamically according to the distance and the distance can be estimated by using a parameter Receiving Signal Strength Indicator (RSSI) between these nodes.

In this work we use RSSI technique [6-7] to estimate the distance and then the relative velocity between two nodes.

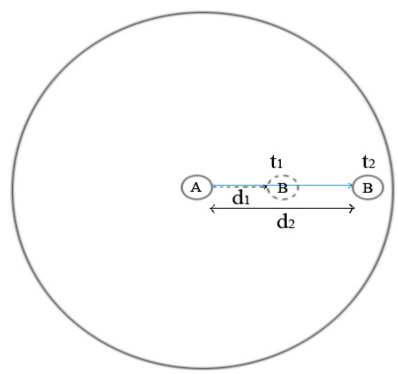

Fig.1: Estimation Of Relative Velocity

In figure 1, $\mathbf{d_1}$ and **d2** are the distance estimated between nodes ***A*** and ***B*** at the time instant $\mathbf{t_1}$ and $\mathbf{t_2}$. We can easily obtain the estimated relative velocity ***Vr*** between ***A*** and ***B*** using the following expression:

$$Vr = \Delta d / \Delta t$$

Where

Δt is the time difference between the former packet receiving (time instant t1) and the next packet receiving (time instant t2) which means Δt=t2-t1.

Δd is the distance difference between the distance d1 and d2 at, respectively, the time t1 and t2.

B. Enhanced Route Discovery Mechanism

The standard AODV protocol always selects the shortest path between source and destination, due to the limited wireless transmission range or the high relative velocity between neighboring nodes, the shortest path is the easiest broken one.

Mobility in MANET causes frequent route breaks. As result, causing a performance degradation of the network lifetime, reliability, energy consumption

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and the network is overloaded to reestablish the route.

On the follow, we present the effect of mobility on the link between two nodes.

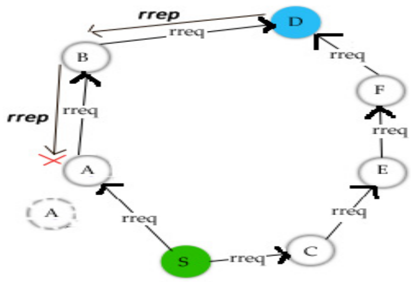

Fig.2 (A): RREP Missing Due To The Mobility Of node A

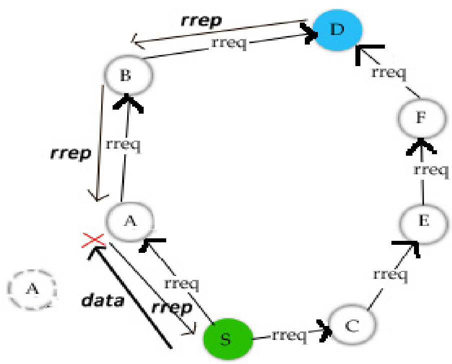

Fig.2 (B): Link Breaks For The Mobility Of Node A

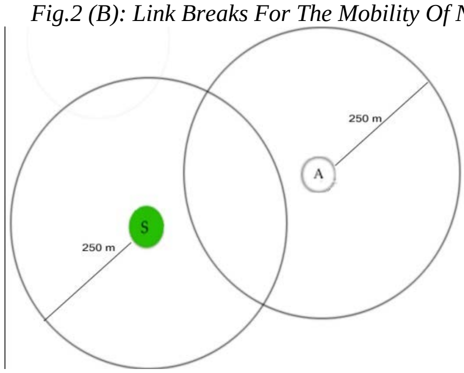

Fig.2 (C): Link Breaks Between S And A

The figure (2.a) illustrates the flow of the RREQ and RREP messages in a scenario where the node A wants to find a route to the node D. initially nodes A, B, C, D and E do not have route to each other.

Node A broadcasts a RREQ message to all nodes within its transmission range, which reaches B and C. Nodes B and C re-broadcasts a RREQ message, which reaches the destination node D that sends back a RREP to the source node A. If a mobile node C moves out of the transmission range of node A, RREP missing will occur and the route discovery process will be useless. We can easily know that several alternative routes built by the RREQ message are ignored.

When the source node S receives a RREP, it can begin, using the route, sending data packets, as shown in Figure 2(b). A route is considered active as long as there are data packets periodically traveling from the source to the destination along that path. Link between nodes A and C may fail due to node C mobility occurs while the route is active, the node A immediately upstream of the break propagates a Route Error (RERR) message to the source node to inform it of the now unreachable destination.

In figure (2.c) node ***A*** moves outward direction and goes out of transmission range of node A due to the limited of transmission range and mobility of node A.

i. Relative velocity between two nodes

The relative velocity between mobile nodes is one of the key characteristics that determine the quality of communications in MANETs. Many aspects of ad hoc networking use velocity estimation (e.g. predicting link lifetime [12]).

Due to the relative movements between mobile nodes, in MANET, The topology changes frequently. This can decrease the performance of communications. Knowing the inter-node relative velocity can help to predict topological dynamics (e.g. link availability prediction [12]) and then optimizing the routing protocols (e.g. mobility metrics [10]).

Let ***Vr*** denote the relative velocity between two mobile nodes ***A*** and ***B***.

If ***Vr=0***, the link between nodes ***A*** and ***B*** is static. If ***Vr*** value is greater than zero the nodes move outward direction, else we assume the nodes moving inward direction, then

The two nodes ***A*** and ***B*** will be connected for a very long time unless change its direction of motion or velocity.

ii. Distance between nodes

Various routing protocols for MANETS [4][8] [23][24] choose the route with the smallest hop count. This results to smaller lifetime of this path. This is because the physical distance between the constituent nodes of every hop in a minimum hop path is about 80% of the transmission range of the nodes during the time of path in the street networks have a high probability of failure[9].

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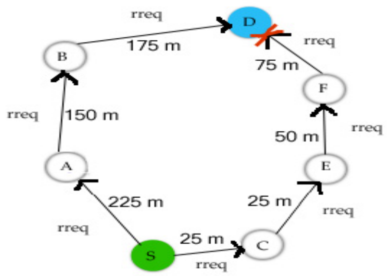

Fig.3: AODV Select The First Path And Discards The Rest

In figure 3, ***S*** is source node; ***D*** the destination node. Transmission range of each node is 250 meter. In standard AODV a path with minimum hop count is selected; the path is ***S→A→B→D***. If node ***A*** moves outward direction and goes out of transmission range of node 0, the path is broken and the route discovery process will be useless. When the first path (first RREQ) is selected, discards the rest.

To enhance route lifetime, we suggest that the distance between nodes would be used. We define the normalized distance of each pair of the nodes as:

$$M_{ij} = \frac{D_{ij}}{Tr_i} \qquad (1)$$

Where:

D$_{ij}$ is the distance between node i and node j and **Tr**$_i$ is the transmission range of node i.

Let consider the previous figure. If the standard AODV is used, the route selected is ***S→A→B→D*** which is the route with minimum hops number. By evaluating the function max(M_{SA},M_{AB},M_{AD})=max(225/250,150/250, 175/250)=90% presents a significant risk that the link drops. But if we choose the route ***S→C→E→F→D*** where max(M_{SC},M_{CE},M_{EF},M_{FD}) = 30% which means that the fragile link(***F→D***) is more stable because the distance between F and D largely less than the transmission range and this will have an influence on the reliability of the route.

Route discovery mechanism

We propose a modification of AODV's route discovery mechanism to allow selection of paths that increase the lifetime of route based on distance and velocity between node neighboring. The source node initiates route discovery procedure by broadcasting RREQ. Each node receiver the RREQ calculates the distance normalized is defined by:

$$M_{ji} = \frac{D_{ji}}{Tr_j} \qquad (2)$$

Where

D_{ji} is the distance between node j receiver and node i sender.

Tr_j is the transmission range of node j sender.

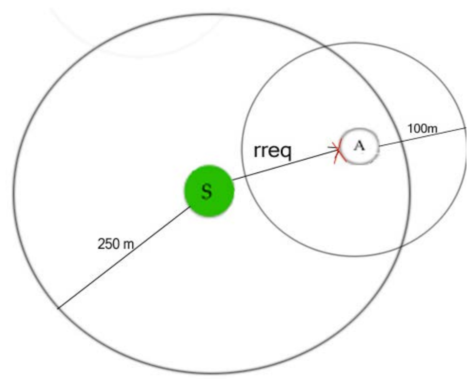

Fig.4a: Presence Of Unidirectional Links

To ensure a bidirectional link in case that the network nodes are heterogeneous, we use the parameter M_{ij}. Then, if M_{ji} is greater than one, RREQ is dropped to ensure that the link between nodes i and j is bidirectional.

We add new field in the RREQ packet as depicted in Table I.

Metric represent the maximal value of the weight function defined in (3) over the path.

Table 1: *RREQ Message Format In MDAODV*

Type	Reserved	Hop Count
RREQ ID		
Destination IP Address		
Destination Sequence Number		
source IP Address		
Metric		

The weight function (f_{ij}) is the parameter that allows nodes to select the best path. This parameter is defined by:

$$f_{ij} = \alpha * \frac{D_{ij}}{Tr_i} + \beta * \frac{V_{r_{ij}}}{Vr_{max_{ij}}} \qquad (3)$$

Where

α and β are the weights satisfied $\alpha + \beta = 1$

D_{ij} is the distance between node i and node j.

Tr_i transmission range of node i

Vr$_{ij}$ is the relative velocity between node i and node j

Vrmax$_{ij}$ is the maximum relative velocity between node i and node j.

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In the following, we give the algorithm of the proposed protocol:

- Calculates RSSI for each node
- Estimates distance between nodes
- **if** node receiver RREQ **and** M_{ji} >1 **then**

DROP RREQ packet
else calculate f_{ij}
endif
if f_{ij}>RREQ→*Metric* **then**
RREQ→*Metric*=f_{ij}
endif

if node is the destination **then**
if receiving first RREQ **then**
RouteTable→*Metric*=RREQ→*Metric* **and** select route
elseif
RouteTable→*Metric* >RREQ→*Metric* **then**
RouteTable→Metric=RREQ→Metric **and** select route
elseif RouteTable→*Metric*==RREQ→*Metric* **and** RouteTable→hopcount > RREQ→ hopcount **then**
RouteTable→*Metric*=RREQ→*Metric* **and** select route
else DROP RREQ packet
endif
else rebroadcast RREQ packet
endif

Our contribution makes the standard AODV conscious to the distance and relative velocity between two mobile nodes when choosing the best route.
Whenever a source node requires communicating with another node for which it does not have a route, it initiates the route discovery phase by broadcasting a Route Request (RREQ) packet to all its neighbors. When a neighboring node received the route request message it checks if M_{ji} is greater than 1. In this case, the RREQ is dropped to ensure that the link is bidirectional else it calculates the parameter f_{ij} defined in (3) and stored f_{ij} in the ***Metric*** field of the ROUTE REQUEST packet. As the RREQ is broadcasted in the whole network, upon receiving the RREQ, an intermediate node first checks whether it has received this RREQ before. If so, it drops the RREQ. The intermediate node checks if the parameter f_{ij} is greater than the ***Metric*** value in RREQ packet. If yes, it sets the ***Metric*** to f_{ij}.
Same as AODV, if a node detects a link break during route maintenance phase, it sends a Route Error (RERR) packet to the source node. Upon receiving the RERR, the source node initiates a new round of route discovery.
The destination node chooses the path whose ***Metric*** value in RREQ is the least among all paths. The evaluation of the parameter will be made by the destination node at each received RREQ message, and the selected route is that the ***Metric*** value is the smallest possible.

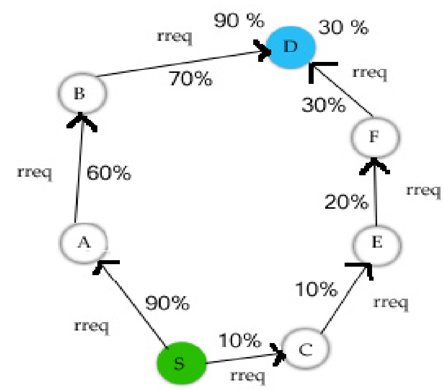

Fig.4b: Our Contribution MDAODV

In figure 4b we present an example applying our approach. We note that AODV protocol selects the first path (***Metric***=90%) and discards the rest. But MDAODV selects the path with (***Metric***=30%) which is less mobile and more stable than the other selected routes and this will have an influence on the reliability of the routes.

3. SIMULATION ENVIRONMENT

To evaluate the performance of the proposed MDAODV protocol, it was tested on NS2 and the simulation result was compared with basic AODV protocol.

A. Simulation Parameters

In our simulations, nodes were initially placed randomly within a fixed size 1500mx1500m square area. We used IEEE 802.11 MAC protocol for nodes in the simulation. Transport layer protocol is UDP, a 30 Constant Bit Rate (CBR) data flows each node generating 4 packets/seconds with a packet size of 512 bytes are generated. Nodes positions were generated randomly. Two-rayground model was adopted. This model [22] considers both the direct path and a ground reflection path. The model gives more accurate prediction at a long distance than the free space model.

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Table 2*: Parameters Of Simulation*

Simulator	ns-2.31
Network area	1500 m x 1500 m
Number network of nodes	10, 15, 20, 25, 30, 35, 40, 45, 50
Heterogeneity ratio	500/100, 500/150, 500/200, 500/250, 500/300, 500/350, 500/400, 500/450
α and β	α=0.5 and β=0.5
Mobility model	Random Waypoint
MAC Layer Protocol	IEEE 802.11
Speed	10 m/s
Traffic type	CBR (UDP)
Data payload	512 bytes/packet
Packet rate	2 packets/sec

Table 2 Shows The Simulation Parameters Used In This Evaluation.

B. Mobility Model

The mobility model is designed to describe the movement pattern of mobile nodes, and how their location, velocity and acceleration change over time.

Various mobility models have been proposed for MANETs in the literature [17-21]. In Broch et al. [16], the authors introduced the random waypoint model which turns out to be the most widely used mobility model. In this model, each mobile node chooses a random destination and moves toward it with a speed uniformly distributed in [0, Vmax], where Vmax is the maximum allowable speed for a node. After reaching the destination, the node stops for a random duration. It then chooses another destination randomly and repeats the whole process. This kind of model has been used in many simulation studies.

C. Performance Metrics

The performance of each routing protocol is compared using the following performance metrics:

-***Packe Delivery Ratio (PDR)*** as a metric to select the best route, transmission rate or power.

PDR is the ratio of the number of number of packets received by the destination to the number of packets sent by the source.

-***Normalized routing load*** is the ratio of the number of control packets propagated by every node in the net work and the number of data packets received by the destination nodes.

- ***End-to-end delay*** is the time it takes a packet to travel across the network from source to destination.

To find the optimal values of α that maximize the network performances, we have simulated the proposed protocol for different nodes density varying α with (β=1- α). The results are depicted in Figure 5.

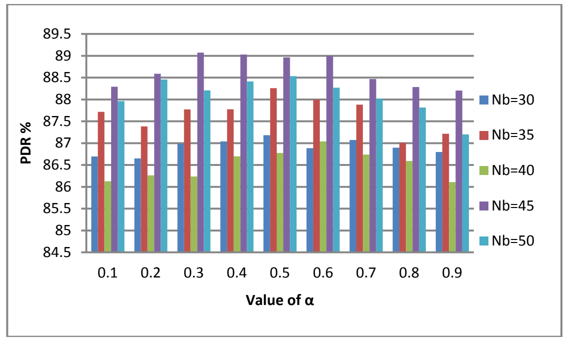

Fig.5: Packet Delivery Ratio Comparison Of MDAODV With Varying Values Of Α

In figure 5 we compared the packet delivery ratio of MDAODV with varying values of α and number of mobile nodes. The results confirmed that the MDAODV with α=0.5 and β=0.5 greater than the others value of α when the number of mobile nodes is 30, 35 and 50.

Results in homogeneous mobile ad hoc Network

In homogeneous mobile ad hoc network all nodes have same maximum transmission ranges.

We have analyzed the performance of the proposed algorithms by varying the number of mobile nodes in the network.

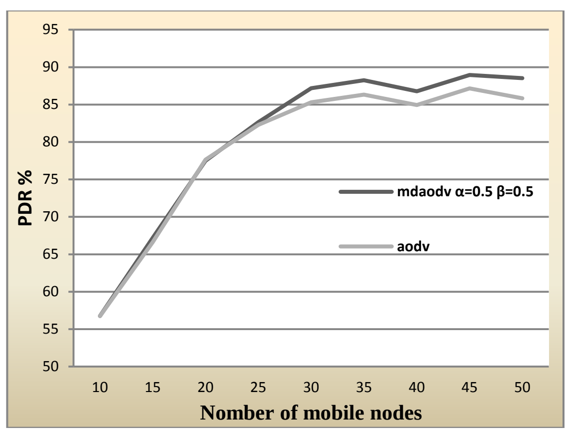

Fig.6: Packet Delivery Ratio (PDR) Comparison

Figure 6 shows a comparison between both the routing protocols AODV and MDAODV (α=β=0.5) on the basis of Packet delivery ratio (PDR) using a different number of mobile nodes, PDR is almost same in two routing protocols for less network size.

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But in a network size of 25, 30, 35, 40, 45 and 50, MDAODV (α=β=0.5) has higher PDR than AODV. By increasing number of nodes brings apparent difference between the two protocols because there are several possible paths in MDAODV that are ignored by AODV.

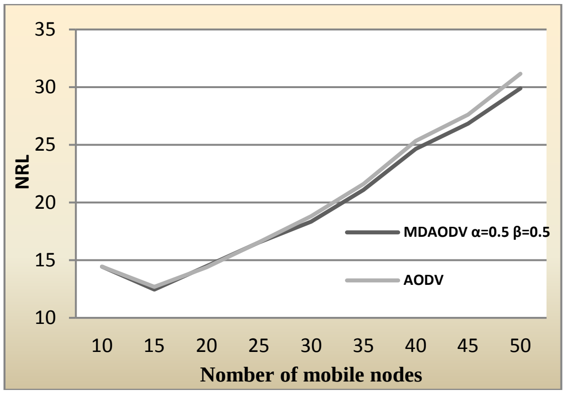

Fig.7: Normalized Routing Load Comparison

Figure 7 shows a comparison between both the routing protocols AODV and MDAODV (α=β=0.5) on the basis of normalized routing load (NRL) using a different number of mobile nodes, NRL is almost same in two routing protocols for less network size But in a network size of 25, 30, 35, 40, 45 and 50, MDAODV (α=β=0.5) is higher NRL than the AODV. By increasing number of mobile nodes brings apparent difference between the two protocols.

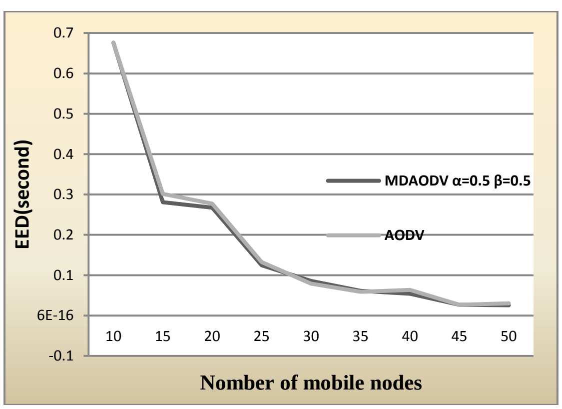

Fig.8: Average End To End Delay Comparison

Figure 8 shows a comparison between both the routing protocols of AODV and MDAODV (α=β=0.5) on the basis of Average end to end delay (AEE) using a different number of mobile nodes, AEE is almost same in two routing protocols.

Results in heterogeneous mobile Ad hoc Network

We have also analyzed the performance of the proposed algorithms by varying the number of mobile nodes and the Heterogeneity ratio between nodes in the network heterogeneous.

Heterogeneous Mobile Ad-Hoc Networks (H-MANETs) are composed of nodes with different transmission range.

Heterogeneity ratio is the ratio of the transmission range of transmitting node to the transmission range of receiving node.

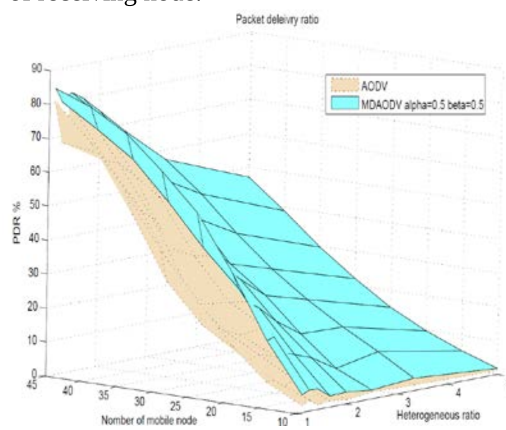

Fig.9: Packet Delivery Ratio (PDR) Comparison

Figure 9 shows a comparison between both the routing protocols AODV and MDAODV (α=β=0.5) on the basis of packet delivery ratio using a different number of mobile nodes and the Heterogeneity ratio, MDAODV (α=β=0.5) is higher PDR than the AODV.

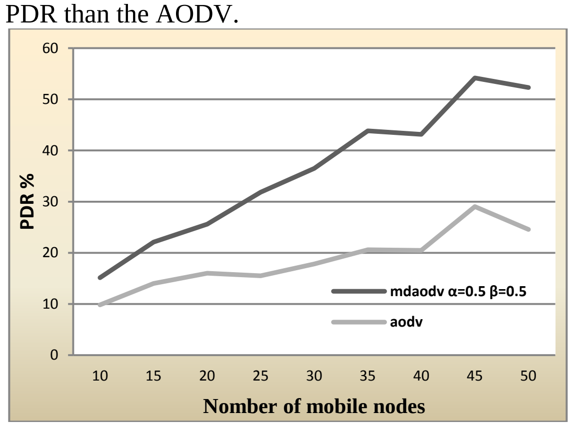

Fig.10: Packets Delivery Ratio With Heterogeneity Ratio=500/250

Figure 10 shows that packet delivery ratio with Heterogeneity ratio=500/250 of MDAODV (α=β=0.5) is higher than the AODV, by increasing number of nodes brings apparent difference between the two protocols because there

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are several possible paths and the link unidirectional ignored in MDAODV (α=β=0.5).

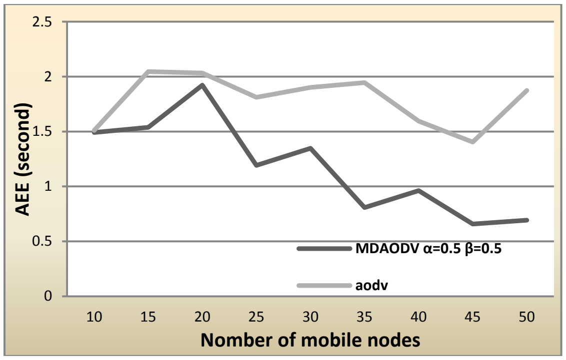

Fig.11:Average End To End Delay With Heterogeneity Ratio=500/250

In figure 11, shows a comparison between both the routing protocols AODV and MDAODV (α=β=0.5) on the basis of average end-to-end delay using a different number of mobile nodes with heterogeneity ratio=500/250, MDAODV (α=β=0.5) has less average end-to-end delay than the AODV.

4. CONCLUSION

Ad-hoc On-demand Distance Vector (AODV) provides best solution for packet routing in mobile wireless ad hoc networks, however, the path selected by this protocol may derivate far from optimal because of inconsideration of distance and relative velocity between sender and receiver that changes when nodes are mobile, resulting in link break. In this paper, an improvement of the AODV is presented. The main idea of this enhancement is based on taking into account the distance and relative velocity when choosing the path. So that, those routes have high stability of link connectivity. Through the simulation, it is confirmed that the MDAODV protocol has higher data package delivery ratio in homogeneous and heterogeneous networks compared to AODV protocol. As future work we will investigate the use of node energy as aggregated metric.

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