Minimum Delay Routing Optimized AODV Protocol in Wireless Networks under Heavy Traffic

A.Priyadharshini, Dr.M.Devapriya

Abstract— **The Mobile Ad Hoc Network (MANET) is a network consisting of a set of mobile hosts capable of communicating with each other without the assistance of base stations. The dynamic topology of a mobile ad hoc network poses a real challenge in the design of a MANET routing protocol. A mobile ad hoc network (MANET) is characterized by energy limited nodes, bandwidth constrained, variable capacity wireless links and dynamic topology, leading to frequent and unpredictable connectivity changes. The propose minimum delay routing protocol is based on the minimum delay path selection using link expiration time and minimum expected delay calculation criteria, regardless of the paths load analysis. According to messages will be delivered to the sensor that has at least a connected path with their hosting nodes, and has the shortest expected delay to communication directly with the sink node. So MAODV use the expiration time of path to indicate the valid time of the path, and avoid wrong transmissions. The proposed minimum delay routing protocol with limited TTL (Time to Live) of RREP packet in which the route reply (RREP) packet of AODV is modified to limit TTL information of nodes. Experiments have been carried out using network simulator (Scalable wireless ad hoc network simulator). Simulation results show that proposed minimum delay routing protocol (AODV) outperforms existing AODV in terms of packet delivery rate, throughput, and delay.**

Index Terms—**Mobile Ad Hoc Networks, Minimum Delay Routing Protocol, Load analysis, Delay and Hop count**

I. INTRODUCTION

A mobile ad hoc network is a collection of wireless mobile nodes that dynamically establishes the network in the absence of fixed infrastructure. One of the distinctive features of MANET is, each node must be able to act as a router to find out the optimal path to forward a packet. As nodes may be mobile, entering and leaving the network, the topology of the network will change continuously. MANETs provide an emerging technology for civilian and military applications. Since the medium of the communication is wireless, only limited bandwidth is available. Another important constraint is energy due to the mobility of the nodes in nature.

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One of the important research areas in MANET is establishing and maintaining the ad hoc network through the use of routing protocols. Though there are so many routing protocols like Ad hoc On Demand Distance Vector (AODV) routing algorithm is a routing protocol designed for ad hoc mobile networks. AODV is capable of both unicast and multicast routing. It is an on demand algorithm, meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. Additionally, AODV forms trees which connect multicast group members. The trees are composed of the group members and the nodes needed to connect the members. AODV uses sequence numbers to ensure the freshness of routes. It is loop-free, self-starting, and scales to large numbers of mobile nodes. The Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on the idea of the classical Bellman-Ford Routing Algorithm with certain improvements. Dynamic Source Routing (DSR) is a routing protocol for wireless mesh networks. It is similar to AODV in that it forms a route on-demand when a transmitting computer requests one. However, it uses source routing instead of relying on the routing table at each intermediate device.

The present routing algorithms can be broadly classified into two categories, *Position based routing protocols* and *Topology based routing protocols* [5].The position based routing protocols are efficient in the sense that they have a lower route discovery overhead as compared to proactive and reactive topology based protocol, which floods the network. The route from source to destination is established by utilizing location Service of the GPS modems attached to each node which helps the node to be aware of its position and position of neighboring nodes. In *greedy forwarding based protocol* a route from source to destination is assigned in terms of shortest geographical distance between source and destination without conforming the compatibility of assigned route for message size which is to be sent from source to destination.

Some of the existing techniques focuses on Position based geometric routing, where the source nodes knows the position of the destination node. To establish a route with minimum delay, they will calculate *End-to-end delay* with its mathematical formulation. The analysis of such formulation will be used to assign routes for an efficient multimedia transmission via parallel links and efficient framing of the data to utilize the available paths effectively reducing the power consumption.

The rest of the paper is organized as follows. Section 2, gives an overview of related work. Section 3 presents proposed approach. In Section 4, deal with some topologies to validate proposed approach. Conclusion is presented in Section 6.

II. Related Work

The previous approaches include an improved version of AODV routing protocol [9] based on the link cost for multi rate MANETs. Where each node transmits a repeat request. RREQ (Route Request) with a predefined time to live. Every RREQ (Route Request) is identified by its sequence number. The first received RREQ (Route Request) is processed and the duplicates are discarded. This process is repeated for reverse path update. But such regular path updating causes network flooding, so many generated RREQs (Route Request) may loss and route discovery procedure may not perform well. Since RREQs (Route Request) are avalanche patters. Another approach [11] is presented as QAODV (Quality of Service Ad hoc On Demand Distance Vector) to improve the delay in using AODV (Ad hoc On Demand Distance Vector) when distances between nodes are closer. The approach is based on only bandwidth as a parameter for routing. However bandwidth may not be sufficient to address QoS (Quality of service) for real-time applications where delay jitters.

A number of extensive simulation studies on various MANET(Mobile Ad hoc network) routing protocols have been performed in terms of control overhead, memory overhead, time complexity, communication complexity, route discovery and route maintenance [4]. However, there is a severe lacking in implementation and operational experiences with existing MANET routing protocols. The various types of mobility models were identified and evaluated because the mobility of a node will also affect the overall performance of the routing protocols. The Existing framework for the ad hoc routing protocols was proposed by Tao using TAODV (Trusted aware Ad hoc On Demand Distance Vector) [2] protocol. This protocol distance based node set. Another OLSR(optimized link state routing) is a proactive link-state routing protocol, which uses hello and topology control (TC) messages to discover and then disseminate link state information throughout the mobile ad hoc network. Topology broadcast based on reverse-path forwarding (TBRPF) is a link-state routing protocol for wireless mesh networks. The obvious design for a wireless link-state protocol (such as the optimized link-state routing protocol) transmits large amounts of routing data, and this limits the utility of a link-state protocol when the network is made of moving nodes. The number and size of the routing transmissions make the network unusable for any but the smallest networks.

To minimize the traffic on wireless network another geographical routing protocol is Greedy Perimeter stateless routing (GPSR), which comprises of two types of forwarding: Greedy forwarding and perimeter forwarding. As the mobility of nodes increases, it also increases the breakages in the routes which results in re-discovering the routes in networks. To avoid such traffic and collision, a new process called Velocity Aware-Probabilistic discovery model is identified [4]. While constructing routes from source to its destination, this model identifies the unstable nodes (having high mobility) from the network and excludes such nodes from route. To manage the load in Ad Hoc network, density probabilistic scheme [4,5] distance based probabilistic scheme, a position aware counter based scheme were identified for minimization of rebroadcasting process.

The metric most commonly used by existing ad hoc routing protocols is minimum hop-count. These protocols typically use only links that deliver routing probe packets. This approach implicitly assumes that links either work well or don’t work at all. While often true in wired networks, this is not a reasonable approximation in the wireless case: many wireless links have intermediate loss ratios. A link that delivers only 50% of packets may not be useful for data, but might deliver enough routing update or query packets that the routing protocol uses it anyway.

III. Proposed Approach

Proposed minimum delay routing protocol is to include exchanging the route information to the neighbor node to find a feasible path. The destination path selection is based on selection criteria such as hop length, minimum power required and life time of the wireless link. Gathering information about the path breaks and broken links for minimum processing power and bandwidth and utilizing minimum bandwidth. One of the most important properties of ad hoc wireless networks is the mobility associated with the nodes.

Main contribution is to analyze and simulate an active probing and learning algorithm using distributed learning to find the minimum mean delay paths in service overlay networks. In a service overlay network, where the performance of the underlying network is random and unknown to the overlay nodes, it is beneficial to actively probe the network performance to find the minimum delay overlay paths. In order to determine minimum delay routes it must probe the current network state. However, it desire a probing scheme that 1) does not inject an excessive amount of traffic just for probing, 2) that scales well to large overlay networks, and 3) that can adapt to change the network conditions.

It builds the reversed routes to the source node by looking into the node that the route request has come from. The intermediate nodes check for fresh routes according to the hop count and destination sequence number, and forward the packets they received from their neighbors to the respective destinations. The proposed minimum delay routing protocol AODV (ad hoc on demand routing protocol) utilizes periodic route discovery packet for route maintenance. If a node does not receive a HELLO packet within a certain time or it receives a route break signal that is reported by the link layer, it sends a route error packet by either unicast or broadcast, depending on the precursor lists in its routing table (i.e. active nodes toward the destination). Proposed AODV (ad hoc on demand routing protocol) avoids the stale route cache problem of DSR (dynamic source routing) and adapts the network topology changes quickly by resuming route discovery from the very beginning.

Proposed minimum delay routing protocol method have limited the TTL(Time to live) value for the RREQ (Route Request) request path and considered the following two states in which TTL is very low. i) Considering the packet (RREQ or any other packet) does not reach a node and remains in the middle nodes, therefore it was discarded. ii) The TTL value is very high, meaning that it allowed a larger number of hops. In this state, the rate of packet delivery was lowered.

The resulting traffic will occupy bandwidth. However, proposed system allows the packets requiring 255 hops or less to reach their destination. For example, when see the hop count is greater than threshold like 256 TTL the packet going to discard.

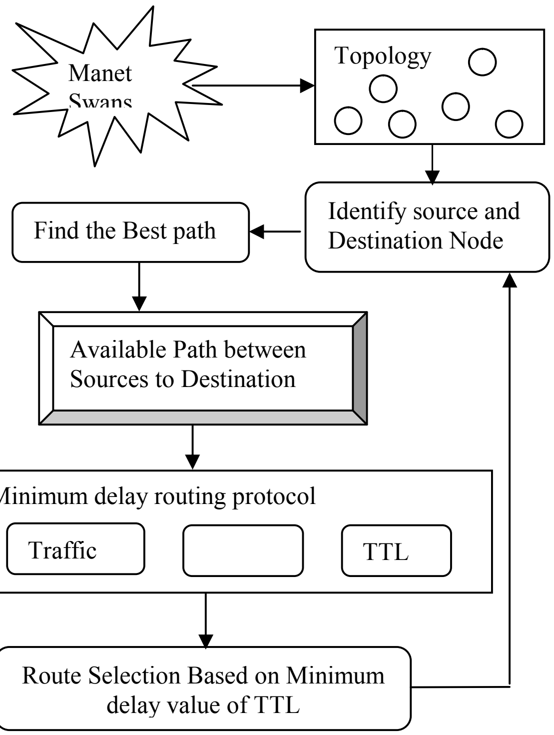

Fig. 1. System Architecture

Proposed protocol limit the hops using a certain no of node only. This leads to improvement of packet delivery rate, throughput, delay and jitter.

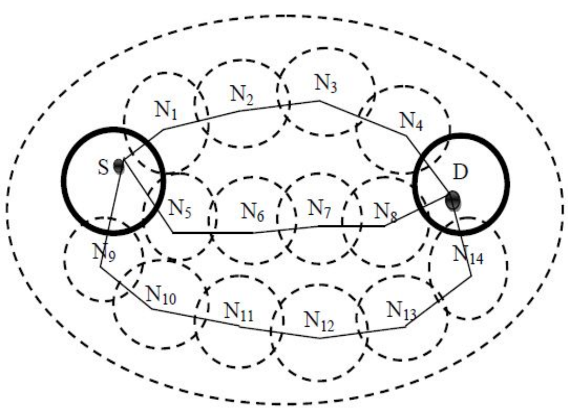

Fig. 2. Source to destination available path

For such a network a greedy forwarding protocol will choose shortest path for transmission without taking care of data rate of intermediate routers.

3.1 Network Model

Random walk based Mobility Models: In random based mobility models, the mobile nodes move randomly and freely without restrictions. To be more specific, the destination, speed and direction are all chosen randomly and independently of other nodes. This kind of model has been used in many simulation studies. To discover and preserve routes between nodes in an active topology with probably uni-directional links, using lowest amount of resources. Normally the main characteristic of MANETs is dynamic topology. The routes are formed with a group of nodes and due to mobility in nature for MANET, links are broken.

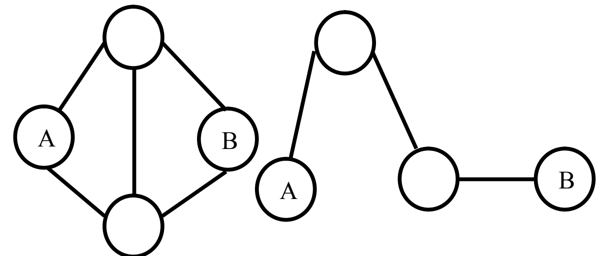

Fig. 3: Dynamic topology of MANET

To improve the data communication in MANET which is dynamic topology in nature has a possibility to access the data.

3.2. Transmission Delay

Delay while establishing an end-to-end communication is the sum of total nodal delays of all the intermediate nodes. It is time taken for a packet to be transmitted across a network from source to destination.

$$d_t = \frac{p}{r}$$

Where d_t is transmission delay and p is packets size and r is data rate. The amount of time consumed to pop out all of the packet bits onto the link constitutes *transmission delay*. This includes the addition of current router information and time for sending the acknowledgement signal to the parent router on successful transmission of message.

3.3. Link Expiration Time and Minimum Expected Delay Calculation

Assume two nodes *i* and *j* are within the transmission range *r* of each other at time *t*. Let the coordinates of *i* and *j* be (x_i, y_i) and (x_j, y_j), the speeds be v_i and v_j, and the moving directions be θ_i.

(1) If the node *i* comes within the communication range of the sink node, then $T_i^S = t$, here *t* is the current time. The time that they will depart can be calculated out, that is, $T_i^S = T_i^E$.
(2) If the current moving path of the node *i*, *i.e.*, the ray L determined by P(*xi,yi*) and θ_i, does not intersect the circle C (the communication range of the sink node), then $T_s = T_E = 0$ since the node *i* will never meet the sink node in the near future $T_i^S = \infty, T_i^E = 0$ since the node *i* will never meet the sink node in the near future
(3) If the above two cases cannot be held, then the ray L intersects with the communication range of the sink node. That means the node *i* is moving toward the sink node and will meet it with considerable probability. Let I1 and I2 be the two intersection points of the ray L and the circle C. Here, we ignore the instance that L tangents to C for the communication time between the two nodes is too short. Then:

$$T_i^S = t + PI_1/V_i$$
$$T_i^E = t + PI_2/V_i$$

where PI1 and PI2 are the distance from P to I1 and I2 respectively, and PI1 < PI2.

3.3. Calculating the Best path

The weight of a path is calculated on the basis of sum of load and delay for that path. The weight can be given as

$$W_i = \frac{TL}{TD}$$

Where W_i is weight of path, TL is total load and TD total delay. This equation is used to calculate the which is the best path for packet sending.

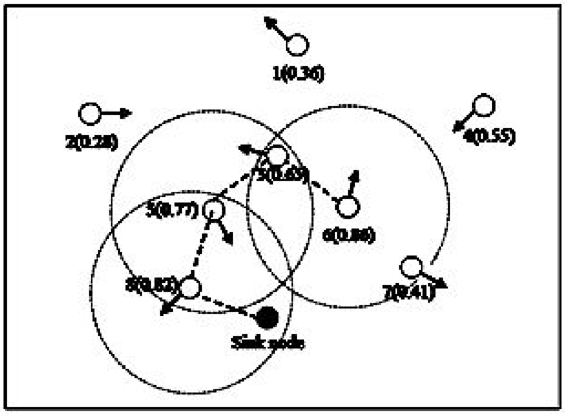

Fig 4. Best next hop selection

There may be heavily loaded networks where minimized load plays a crucial role. Also there may be networks where minimized delay is preferred over load. For coping with this situation above formula can be modified as

$$W_i = PL \times TL + PD \times TD$$

Where W_i is total weight path between source and destination and PL, PD are that sum to one, the path is selected otherwise path cannot taken for packet routing. These values may be varied depending on the selection path. For past situations PL is greater than PD vice versa. This calculation is applied for every node in the path to find weight value. Total weight is the sum of weights of all nodes in the path. Therefore multiple paths with varying weighted value, after which on is minimum weight value are selected for packet routing.

3.5. Route selection process

The destination node will wait for t time for the arrivals of RREQs, and then computes the route selection function for all available routes to the destination. The route with maximum Route Selection Function value will be selected as the candidate route. The Route Selection Function is given by following equation:

$$\text{Route Selection Function}(i) = \frac{PF_{sdi} + CF_{sdi}}{L_i}$$

Where PF_{sdi} is Power factor for a particular source and destination pair of path I , CF_{sdi}value of all nodes along a valid path are multiplied to obtain the congestion factor value for this path and L_i Actual Length Route of route. It can achieve higher performance with regards to end to end delay, traffic load and energy consumption. See figure 5 to find best path where π is probability value of prior knowledge of the path.

The minimum delay paths: hop-by-hop learning and end-to-end learning. In hop-by-hop learning, as illustrated in Fig. 5, each intermediate node on the forward path from a probe's source node S to its destination node D also receives feedback and performs learning updates. In end-to-end learning, only the source node S of the probe can learn from the end-to-end performance measured by the probe, which is easier to implement at the cost of slower learning speed.

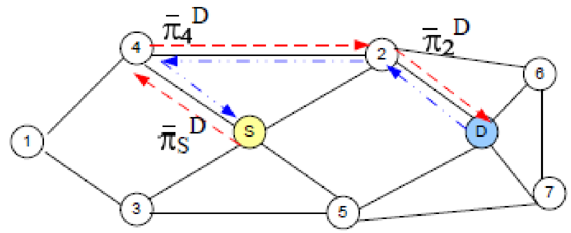

Fig 5. hop-by-hop learning of the optimal path from node S to destination node D.

This means that if the condition applies, we consider the last hop for the last TTL (i.e. the packet has used its authorized hop). However, if the condition does not apply, meaning that the packet wants to use a larger number of hops to reach its destination, the packet is discarded; because if we increase the number of hops, it will take the packets longer to reach their destination; therefore, resulting traffic will occupy bandwidth. However, we freely allow the packets requiring 255 hops or less to reach their destination. For example, when we see a packet pass the 256 threshold, we limit the hops using a certain condition. This leads to improvement of packet delivery rate, throughput, delay and jitter. Consider a specific MANET topology, where there are three different possible configurations of routes from source to destination, there route parameters are tabulated as follows.

Table 1: Minimum delay routing

Route no.	No. of Hops	Distance	Data rate
1	4	10	35
2	5	100	45
3	6	150	54

PSEUDO-CODE FOR PROPOSED ALGORITHM:

Source node S wants to transmit data packet to destination node D

```
Step1: Send the Request Packet and set the hop count
   Value=255.
Step2:  ReceiveReply (Packet P){
          if(P has an entry in Route Table){
          select Dest_Seq_No from routing table
Step3:  if(TTL_P.Dest_Seq_No > TTL_Dest_Seq_No){
          update entry of P in routing table
          unicast data packets to the route  specified in RREP
          }
          else {
            discard RREP
                    }
          }
          else {
          if(TTL_P.Dest_Seq_No >= TTL_Src_Seq_No){
          Make entry of P in routing table
   }
```

```
Step5:else {
        discard this RREP
        }
        }
```

Step4: Calculate best path on the basis of Route Selection

```
        Pre_ReceiveReply (Packet P){
        t0 = get(current time TTL value)
                t1=t0 + MOS_WAIT_TIME
                while(CURRENT_TIME <= t1){
        Store P.Dest_Seq_No and P.NODE_ID In
        RREP_Tab table
        }
Step5: while (RREP_Tab is not empty) {
         Select Dest_Seq_No from table
        if (TTL_Dest_Seq_No >>>=TTL_Src_Seq_No){
                discard entry from table
                }
                }
        select Packet q for Node_Id having
        highest value of Dest_Seq_No
        ReceiveReply(Packet q)
}
        }
```

IV. Experimental Results

To conduct the experiment a network is considered. This network comprised of maximum 80 nodes placed randomly within 1000m×1000m area. Each node sends out four packets per second with the size of CBR fixed at 512 Bytes. The node moves randomly towards a random spot until it reaches that spot, then it pauses and move again. Different values of pause time and speed are tested in the same topology to simulate the protocol. Java SWANS simulator has been implemented to evaluate the performance of the used network. Different parameters in the simulation are given in the following table.

Table 2: Network parameters for AODV Simulation

Simulator	SWANS
Protocol	MAODV
Simulation area	1000m X 1000m
Simulation duration	200 Second
Number of nodes	20,40,60,80
Transmission range	250 m
Movement model	Randomwalk Model
MAC Layer Protocol	IEEE 802.11
Pause time	100 sec
Maximum speed	20 m/s
Packet rate	4 packets/sec
Traffic type	Constant bit rate Error
Packet Size	512 bytes/packet

4.1 Performance Metrics

PDR is the ratio of the number of data packets received by the destination node to the number of data packets sent by the source mobile node. It can be evaluated in terms of percentage (%). This parameter is also called "success rate of the protocols", and is described as follows:

$$PDR = \left(\frac{Send\ Packet\ no}{Receive\ packet\ no}\right) \times 100$$

Throughput is the average rate of successful message delivery over a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node.

$$X = \frac{C}{T}$$

Where X is the throughput, C is the number of requests that are accomplished by the system, and T denotes the total time of system observation.

Average end-to-end delay Average end-to-end delay signifies how long it will take a packet to travel from source to destination node. It includes delays due to route discovery, queuing, propagation delay and transfer time.

$$D_{end-end} = N(d_{trans} + d_{prop} + d_{proc}$$

Where dend-end= end-to-end delay, dtrans= transmission delay,dprop= propagation delay,dproc= processing delay,dqueue= Queuing delay and N= number of links.

This metric is useful in understanding the delay caused while discovering path from source to destination.

Jitter is often used as a measure of the variability over time of the packet latency across a network. A network with constant latency has no variation (or jitter). Packet jitter is expressed as an average of the deviation from the network mean latency.

$$jitter(i) = delay(i + l) - delay(i)$$

Where l is the no of links, i=1,2…N Jitter is the variation of the packet arrival time. In jitter calculation the variation in the packet arrival time is expected to minimum. The delays between the different packets need to be low if we want better performance in Mobile Ad hoc Networks.

TTL (Time to live) is a method that limits the lifetime of data in a computer or network. TTL may be implemented as a counter attached in a packet in the network. When count is reduced to zero or time span has elapsed, data is dropped or discarded in the data network.

Proposed algorithm limit TTL (time to live) value for route request packet (RREP) that broadcasts periodically or when an event occurs in the network for finding the path to the destination node (e.g. limited to 128 or 256; this value varies depending on network size or network topology). This value is not lower than threshold (as the threshold depends on network size or network topology, this value is variable too). Since in this case, the packet (RREP or any other packets) does not receive to the destination node and drops or discards in the middle node. This current packet routing table TTL value is lower than updated TTL value, because packets maintain long time in network and then increase the traffic, packet delay, jitter and decrease packet delivery ratio and throughput in network.

V. Performance Comparison

The simulation results are shown in the following section in the form of line graphs. Performance of regular AODV and minimum delay routing protocol MAODV based on the varying number of nodes in chain topology is done on parameters like packet delivery ratio, delay and throughput.

Table 3: Packet Delivery Ratio

Protocols	No of Nodes						
	20	30	40	50	60	70	80
AODV	50	53	61	70	73	71	69
MAODV	62	67	85	83	81	84	85

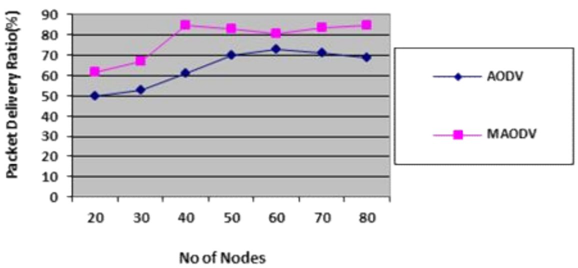

Fig. 6. Compare packet delivery ratio Vs protocols

Fig .6 shows packet delivery ratio against the number of nodes. It shows that the improved MAODV protocol has a better throughput in the TTL time range of 20 to 80 nodes (above 20%).

Table 4: Compare Throughput

Protocols	No of Nodes						
	20	30	40	50	60	70	80
AODV	4.1	4.2	3.8	4.1	4.8	5.2	6.7
MAODV	4.8	4.5	3.86	4.7	5.3	6.6	7.4

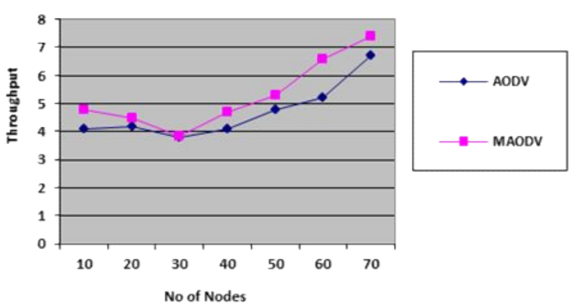

Fig. 7. Compare throughput Vs protocols

Fig. 7 show throughput against the number of nodes. It shows that when the number of nodes is 40, the improved MAODV has fewer throughputs than regular AODV, respectively; however, generally it is better than existing AODV protocol.

Table 5: End to End delay

Protocols	No of Nodes						
	20	30	40	50	60	70	80
AODV	4.8	4.2	3.9	3.5	2.7	2.3	2.0
MAODV	4.3	3.6	3.1	2.7	2.1	1.8	1.2

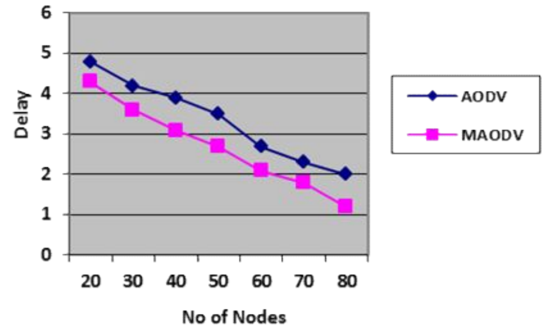

Fig. 8. Compare delay Vs protocols

Fig. 8 show delay against the number of nodes. It shows that when the number of nodes low it take more delay time. The MAODV has lower delay value compared to existing AODV.

Conclusion and Future Work

Proposed minimum delay routing protocol MAODV compare with existing AODV protocol. In proposed MAODV modified TTL value for route selection procedure then the destination node unicast the route reply to the path, having less congestion and maximum energy MAODV protocol with enhanced route discovery mechanism which takes into account the energy and congestion factor to select the most efficient route which can give the better performance in MANET. The proposed protocol by limited TTL (Time to Live) of RREP packet of AODV is modified to limited TTL information of nodes, and evaluated the three performance measures (i.e. PDR, throughput and jitter with different number of nodes). Simulation results show that the TTL limit AODV protocol has a distinct advantage in terms of packet delivery ratio (PDR), throughput and jitter over the existing AODV protocol (approximately 20%). This protocol may extend network lifetime, route availability and increase the packet delivery ratio. Simulation of MAODV is future work.

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