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DYNAMIC MULTI-PATH ROUTING PROTOCOL HINGED ON FITNESS VALUE USING GA IN MOBILE ADHOC NETWORKS

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ABSTRACT

A MANET is a cluster of different wireless hardware devices connected together temporarily hinged on the frequency in the absence of any framework. Owing to a node's periodic mobility, the network's node layout will regularly alter, creating unstable connectivity and a reduced delivery rate. The Collision of packets in the network is the prime obstacle in the wireless network caused by the node's mobility in different manners with arbitrary speeds that leads to the increase in the collision possibility reflected in overall throughput, and delay between the nodes. Here, we proposed a flexible multipath protocol dependent on the fitness values and genetic algorithm. To choose the optimal path among the multiple paths available to deliver the packets we used the fitness function value (FF). Later we equate our proposed algorithm with HACO-FDRPSO and AOMDV-TC. Performance computation for the proposed algorithm was computed by various parameters such as packet delivery ratio(PDR), throughput (Th), End to end-to-end delay (e2e), and Energy Consumption(Ec).
Keywords: *Unstable Link, Fitness Value, Genetic Algorithm, Collision, Energy, And Flexible*

1. INTRODUCTION

In an ad-hoc wireless network, every node will act as a host and modem so that it can transmit and collect the data through the communication channel, and identify the path to the destination with the help of routing algorithms in MANET. Few of the attributes of the ad-hoc network were independent in their operations, Constraints on the bandwidth, topology behavior, and energy-constrained and unstable links. The main advantage in adhoc networks is that with less infrastructure we can connect to the web via routers which leads to less cost [1]. In spite of various approaches, we have a handful of pitfalls in mobile adhoc networks such as depletion of battery in terms of energy when the node was moving leads to upgrading the battery levels and frequent link breaks due to topology change leads to high packet loss [2]. To overcome the hazards many researchers suggested an efficient protocol to enlarge the overall system lifespan and successful data delivery during the transmission by interpreting the energy consumption [3]. On the contrary, as a result of node mobility in the network will turn to unstable links with high collisions between the nodes. The continuous changes made in the arrangement of nodes will result in finding the optimal path multiple times using an efficient algorithm [4].

In mobile adhoc networks, the stability of link characteristics will have a significant effect on real-time applications such as online games, where mobile users will play simultaneously and suffer with more fullback. When the links between the nodes are breaking habitually the mobile users will be reduced to playing games using applications [5]. Because of excessive movement between the nodes the traffic in the network will get higher and result in heavy collision which in turn causes more loss of packets. Due to heavy loss of packets, the network performance will achieve lower results in various scenarios such as identifying the place i.e. while locating the area if any packets are not received in the expected duration due to traffic the optimal path will not be able to be determined exactly [6].

In an adhoc wireless network, a large amount of data or control packets are transmitted in one channel which also surpasses the volume of a network outcome in the congestion of data. If congestion occurs in the network the delay between the nodes will get high and more expenditure is required for recovery and more energy is depleted [7]. Congestion performs a vital part in the battle fields and delay also performs a vital part in the recovery functions and medical organization. In MANET, due to unknown awareness of the dynamic arrangement of nodes in the network, the nodes do not know their neighboring information correctly. When the node moves from one location to another, each node should broadcast its updated location to all its neighbours. By using this the optimal path between the origin and target node will calculated and packet transmission also done using the same path in the network. To do this an efficient wireless multi-path protocol was proposed [8].

The adaptive multi-path algorithms in MANET like AODV, AOMDV, and DSR protocols reduced the traffic issues in the network by using multiple channels. This results in an increase in the performance of the network. The enhanced genre of AODV (adhoc on-demand distance vector) routing protocol was AOMDV (adhoc on-demand multipath distance vector) protocol that identifies the multiple routes between the origin node to this target node within two stages i.e. route discovery process and route preservation. The primary benefits of this routing protocol include finding the routes dynamically when needed, speed connectivity among the nodes, and coherent retrieval from the collisions [10].

A genetic algorithm(GA) is a kind of enhanced search algorithm inspired by the process of legitimate selection and the fundamentals of genetics. GAs are used to determine approximate solutions by using factors such as Initial Route selection, Fitness function, cross-over, mutation, termination, and solution extraction. From the possible route solutions concerning the higher fitness rate, the GA will choose the best solution [11].

2. LITERATURE REVIEW

Chen et al. [12] developed an energy ware multipath routing algorithm concerning on the queue length. This protocol concentrated on how to equity the load and utilization of energy during the transmission and also defines the queue length for each congestion level. Based on the congestion level the selection of the route had been done. Nishit Manishbhai et al. [13] proposed a genetic algorithm-related protocol that will select the optimal route between the mobile nodes through the medium of operations called mutation and cross-over functions. The final route selection was made by comparing the energy utilized and the distance of connecting nodes.

Shah et al. [14] proposed an adaptive routing protocol using the base of a bio-inspired genetic algorithm(AOMDV-FG) to choose the optimal route to the target node. By considering the fitness rate of every link the final path selection was made which gives better performance to the network. Saleh A, Alghamdi [15] introduced a Load-Balanced(LB) routing procedure by using highest and lowest values of residual energy (MMRE) in the on-demand multi-path routing protocol. The LB-MMRE-AOMDV protocol computes the path by finding the values of maximal and minimal residual energy of each node before the transmission of packets.

S Santhosh and B Narasimhan [16] presented a genetic algorithm(GA-CARP) to reduce the congestion in the route. In this paper, they used chromosomes (temporary paths) and genes as parameters to reduce the congestion in the network by performing cross-over and mutation operations. S Sathya et al. [17] proposed an optimal queue selection approach to improve the fairness of the TCP flow of uplink and downlink. Two separate queues are maintained for ack packet and data packets. Based on the ranking the best queue was chosen for organizing the flow. Anuradha B et al. [18] proposed a routing protocol ERL-AOMDV that conducts inquiry more extensively than the remaining energy of the node. The protocol analyses both the residual lifespan of a node and the estimated total time in a network to select the best path.

Mahmoud M et al. [19] suggested an energy-aware routing protocol using AOMDV. The path selection is done by examining the energy specification on behalf of counting the number of links to minimize the battery utilization and enlarge the lifespan of the network. While choosing a path the nodes which having low power will be rejected. Bhavna S et al. [20] proposed a scheme E-AOMDV routing protocol. The path selection was made in account of load balancing, energy consumed, and distance in the network. While selecting the optimum route the scheme identifies the current energy status of the node to select the node for transmission in the network. Lu Guo and the fundamentals of genetics. GAs are used to and Peng Li [21] designed a routing algorithm by balancing the load and energy consumed. The selection of nodes will be done by considering the minimal queue size of the MAC layer and nodes which having maximum energy to distribute the packets into the network.

M Nabati et al. [22] presented an AGEN-AODV routing protocol for heterogeneous ad-hoc networks. The routes are selected in reference to the rating of different parameters such as network steadiness, congestion, and energy. The optimum route selection will be done by using automation and genetic algorithms. CK Brindha et al. [23] suggested to use of a multi-metric quality of service routing technique. The optimum route decision is done by multiple metrics such as energy, delay between the nodes, and power of a node. Dhurandher et al. [24] proposed a routing protocol i.e. GAER based on Genetic Algorithm and energy consumed. Here the protocol maintains mobile node personalized information to select the next hop then applies the genetic algorithm. The chosen immediate neighbor node among multiple nodes will expand the performance of the network.

N Papanna et al. [25] suggested a multicast route approach (EELAM) using an adaptive genetic algorithm. The proposed scheme deals with the tree arrangement of nodes in the network to choose the adjacent nodes with high residual energy and low batter usage. Farsi M et al. [26] designed a collision awake clustering & and routing protocol to minimize the traffic problems in the system. For picking the route from the network the main cluster head and secondary cluster head were used to decrease the flow of data and increase the lifespan of the network.

3. PROBLEM STATEMENT

The primary issue caused by traffic on a single channel when data is being transmitted over a network is packet collisions. In an adhoc wireless network, frequent topology changes between the mobile nodes with different mobility speeds turn into a high collision between the data packets will directly degrade the network performance and due to frequent node mobility the stability of the link will result in higher packet drops results in low packet delivery ration and increased retransmission of the data packets. More due to the collision of packets the delay among the nodes and energy consumption of a node will also decrease the overall network performance.

4. PROPOSED SOLUTION

In order to prevent packet collisions caused by increased traffic and network instability brought on by frequent changes in mobile nodes. we proposed a vital solution that enhances the optimal path selection using the genetic algorithm and also with fitness function value which we introduced by using the adaptive multi-path routing protocol i.e. AOMDV.

5. FITNESS FUNCTION(FF)

In the part of optimal path selection, we have to choose the path that doesn't have collision among the nodes. To keep away from the collision, we transmit two control packets RTS (Ready to Send) and CTS (Clear to Send) to avoid the hidden-terminal problem in the wireless network, and is denoted by C_f

Figure 1 shows the step-by-step procedure for avoidance of collision by using two control packets. In the first step, we will examine whether the channel is in an active or passive state. If the channel is in an active state, the origin node will transmit the RTS control packet to the target node otherwise we will hold back for a random time. If the origin node does not receive a clear to send a CTS packet from the target node denoted as C_f=0 says that collision is detected again we have to wait for a random time. When the target node is available it will transfer the CTS packet to the origin node. when the origin node receives a CTS packet it will transmit the data packet. Once the data packet is collected by the target node it sends an Acknowledge ACK packet to the sender i.e. the transmission of the data packet is successful without any collisions in the network.

The formula used is:

$$C_f = \begin{cases} 1/RT_T, & CTS\ received \\ 0, & CTS\ not\ received \end{cases} \quad (1)$$

Where C_f denotes the collision fitness value based on the packets received

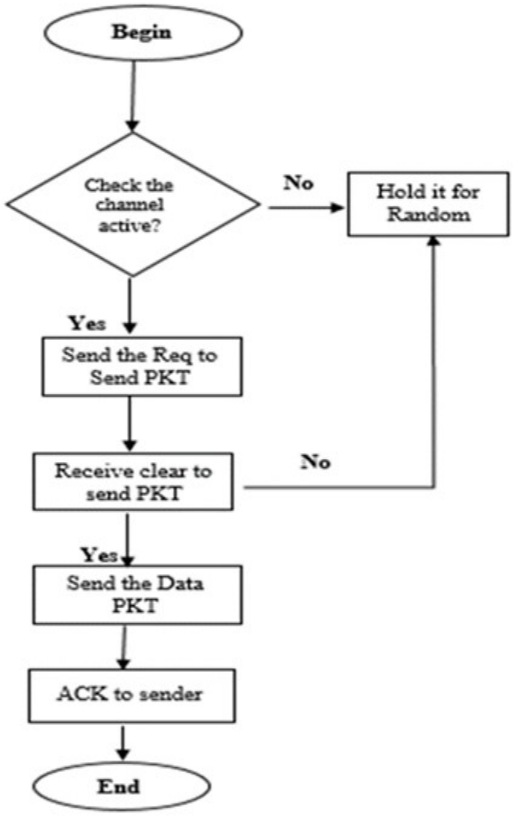

Figure.1: Path Selection Using CSMA/CA protocol

In the AOMDV procedure, next, we determine the length of the queue since every node is available in the path by using equation (2). Where LQ denotes the length of the queue, FEQ allocated frequency, and ST is the smallest time in RT_T

$$LQ = FEQ(RT_T - ST) \qquad (2)$$

Next, Assign the threshold (Th) value to the upgradable queue length. Where K is the stable value between 1 and 0 and LQ_{max} denotes the maximum length of the queue.

$$Th = K * LQ_{max} \qquad (3)$$

Based on the values of LQ and Th, we determine the position of the congestion in the network. If $LQ > Th$, the congestion is identified in the particular route and results in a few packet drops better not to choose that route. If $LQ \leq Th$, congestion is very low, and no packet drops in that route we can choose it as the optimal route based on their fitness values. Based on $LQ \leq Th$ condition the values of QL_f are determined either to be set as zero or some value. Where BF denotes the size of buffer when $LQ \leq Th$ is correct i.e. route is chosen for the transmission of packets. otherwise, congestion is available in that route i.e. $QL_f = 0$

$$QL_f = \begin{cases} 1 - LQ/BF, & LQ \leq Th \\ 0, & LQ > Th \end{cases} \qquad (4)$$

Finally, we will determine the SL_f stability of the link is evaluated based on the radio signal-to-noise ratio(SNR) and packet error rate(PER). SNR is the strength of the signal received from the target node, a larger value indicates a more stable link. Whereas PER indicates that any extra bits received from the transmitter apart from the total bits transferred.

$$SL_f = SNR * PER \qquad (5)$$

In algorithm1, the fitness value (FV) is determined by the total of all the arguments we had computed above i.e. collision value, length of the queue, and link reliability. The computational formula to determine the fitness rate is shown in equation (6).

$$FV = C_f + QL_f + SL_f \qquad (6)$$

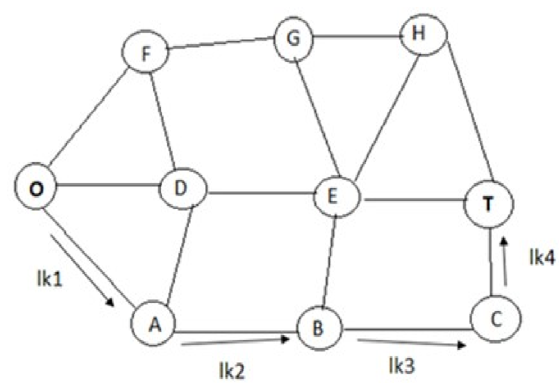

Figure. 2: Path selection in AOMDV protocol

Algorithm 1: Computing Fitness Value for each route
I/P: The multiple received from the protocol AOMDV-FGV 1. C_f = Collision Function for the fitness function 2. QL_f= length of the queue for the fitness function 3. SL_f = Stability of a link for the fitness function 4. N_r = Possible number of routes O/P: Set of values from the fitness function 5. Initialize a to 0

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While (a <= N_r)
    C_f = eq (1)
    QL_f = eq (4)
    SL_f = eq (12)
    F_Vavg = eq (14)
  if ( C_f ≤ F_Cavg )
     else if ( QL_f ≤ F_QLavg )
        else ( SL_f ≤ F_Vavg )
          FV = C_f + QL_f + SL_f
        end else
     end if
  end if
end while.
```

For example, figure 2 clearly shows the number of links available to the target node T from the origin node O (lk1, lk2, lk3, lk4). Determining all the argument values of each link such as $C_f, and\ SL_f$ and assigned to F_{Vava}. To calculate the threshold value, we will determine the medium of each fitness value and check whether their fitness values are higher than the medium value.

$$F_{Vavg} = \sum_{x=1}^{i} \sum_{y=1}^{j} F_{vxy} \Big/ i * j \qquad (7)$$

Where F_{Vavg} is the fitness values in every y link from j links in the x routes out of i number of nodes

6. METHODOLOGY

Initially, we assign a distinct number for every mobile node in the network with a certain uniform energy value. Then after origin and target nodes are chosen in the communication for data conveyance among the nodes as a consequence of route request and route reply packets. After the using AOMDV multipath routing protocol, we determine the multiple routes to the target node without collision by using the above equations. Depending on the fitness rates of each route the higher fitness value route is chosen for the data transmission which more efficient and optimal path among all the routes.

The step-by-step procedure in the genetic algorithm(GA) comprises initialize, fitness value computation, selection, cross over and mutation are followed in the sequence to compute the optimal path. The step-wise procedure of the suggested algorithm AOMDV-GFV in algorithms 1 and 2. Figure. 3 shows the overall procedure of the proposed protocol stepwise

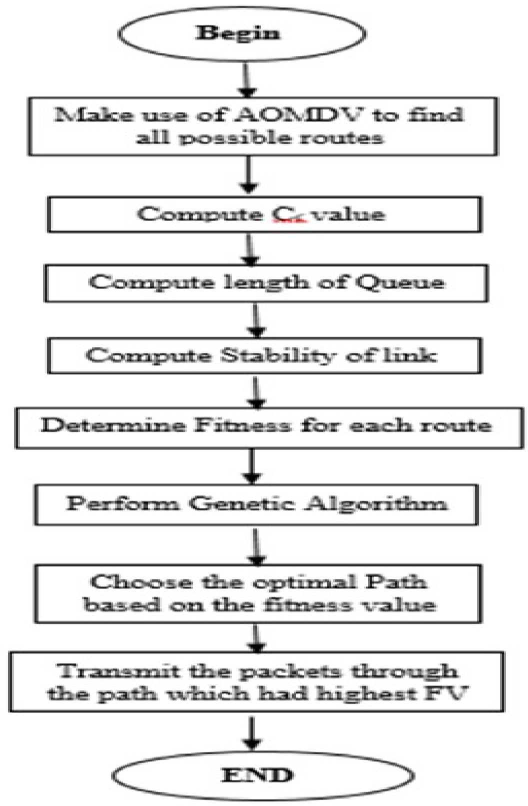

Figure. 3: Proposed Protocol Flowchart

1) Firstly, we will receive the multiple routes from the AOMDV protocol which are available from the origin to the target node. We chose the route based on the minimal length of the path.
2) After that we determine the FV of each route by using equation (6) using the elitism function through equation (7), we will choose greater fitness value routes for the cross-over function.
3) Computing the cross-over function for each route to get the latest route Cr
4) For each latest route we will apply the mutation method to get other possible routes with Cm.
5) Perform the survivor function for each latest route by computing fitness value. A larger fitness-value route will be chosen and other low-fitness-value routes will be removed.
6) Arrange all the routes in big to small order based on their fitness value. A larger fitness value route is chosen for the packet transmission.
7) Furthermore, due to any sudden interrupt of the link break in the route the next higher fitness value route is chosen for transmission in the network

```
Algorithm 2: AOMDV-GFV Routing
Input: All possible routes
Output: Optimal Route Selection
1.  Initialize Mp = 0.1 and Cp = 0.5
2.  Read FF = Fitness_Function ( )
3.  PoR = Possible Routes from S to D
4.  Farr[  ] = none;
5.  Cn = 0, Co = 0;
6.  Begin
7.  For Each Route in PoR
8.  |   While (FP(PoR) = NPr )
    |   |     F_CrossOver (Cp,NPr,OPr) = Cn
9.  |   |    F_Mutation (Mp,ch,Np) = Cn
10. |   |   F_Function (Group of Cn) =Fnc
11. |   End While
12. |   For Each Route in Fnc
    |   |   If (Foc < Fnc) then
    |   |     Farr[  ] = Fnc
    |   |   End if
13. |   End for
14. End for
15. Return_Value Farr[  ]
16. End
```

To make it more clear of our algorithm, let us take an example network in the figure. Suppose O is the origin node and T is the target node. In the network there is no route from O to T. We desire to go for route identification process by using the route request and route reply packets. The mobile node O floods the RREQ packet to their neighbor nodes F, D, and A which again floods to their neighbors G, E, and B until it reaches to node T. The first path O-D-E-T is chosen to send the packet. Furthermore, we also choose the next optimal path if any link breaks have happened i.e. O-A-B-C-T.

The available paths from O node to T node are:
Path-1: O-D-E-T
Path-2: O-F-G-H-T
Path-3: O-D-E-H-T

For each and every path we have to determine their fitness value i.e. for path-1, path-2, and path-3 are 5.2, 8.4, and 8.2. The average value of FV is 7.2. In the selection phase, the paths that are less than the average are removed, here we remove path 1. Next, we apply mutation and cross-over operations results in new paths i.e.

Path-4: O-A-B-C-T
Path-5: O-A-B-E-H-T

The path-4 and path-5 fitness values are 8.8 and 7.9. based on their fitness values we add them into selection paths. Here path-4 was chosen due to its highest FV value path-2 will used further if any failure happens in the transmission

7. SIMULATION & PARAMETERS

A different parameter was used to determine the interpretation of the suggested protocol in accordance with the fitness value. The values of the parameters are indicated in Table 1. The efficiency of the proposed algorithm is calculated in various parameters such as Throughput, Packet Delivery Ratio, end-to-end delay (EED), and Energy Consumption(EC).

7.1 Packet Delivery Ratio (PDR): Measures the proportion that indicates the percentage of datagrams delivered successfully during the transmission from the origin to the target compared with the overall amount of packets sent.

$$PDR = \frac{\sum P_t}{\sum P_g} * 100\% \qquad (8)$$

7.2 Throughput: It is used to measure the amount of data transmitted in the network within a stipulated time frame and it is expressed in megabits per second(Mbps). To transfer data fast from the origin to the target node we need greater throughput.

$$Th = \frac{\sum T_d}{T} \qquad (9)$$

7.3 End to End Delay: It is used to measure the time spent to travel the data away from the origin to the target node in the communication during the transmission.

$$EED = T_t + T_p + T_q + P_d \qquad (10)$$

Where T_t is the Transmission delay, T_p is the Propagation delay, T_q is the queuing delay and P_d is the Processing delay

7.4 Energy Consumption (E_c): It is used to measure the energy depleted during the transmission of all the packets within in stipulated period of time.

$$E_c = \sum(I_n - R_t) \qquad (11)$$

Where I_n is the initial energy of each node at the beginning of the transmission and R_t is the remaining energy during the transmission at a specific time.

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Table. 1: Parameters Used For Simulation

Kind of the Parameter	Specification Value
Simulator	NS 2.34
Dimensions of X & Y (Topology)	1000 m X 1000 m
Simulation_Time in sec	10- 100
Nodes	100
Channel	Wireless
Node Mobility Max Speed	10-100 m/s
Cross Over (C_p) Probability	0.5
Mutation (M_p) Probability	0.1
Initial_Energy	120 J
Antenna Propagation Standard	Two Ray Ground
Wireless Channel	IEEE 802.15.1
Traffic_Kind	TCP, ftp
Transmission Range	500M
Protocols Used	AOMDV-GFV, AOMDV-FFV, AOMDV-TA, HACO-FDRPSO

8. RESULTS

8.1 Packet Delivery Ratio (PDR):

Figure 4 and 5 shows the packet delivery ratio for proposed and other protocols. It seems that a large amount of control packets is needed to identify the optimal route in the system. If the traffic is huge in the network results in congestion and more dropped packets will affect the performance of the network. The proposed protocols AOMDV-GFV and AOMDV-FFV achieve larger PDR values compared to other HACO-FDRPSO and AOMDV-TC protocols due to their lower fitness values their routes are discarded.

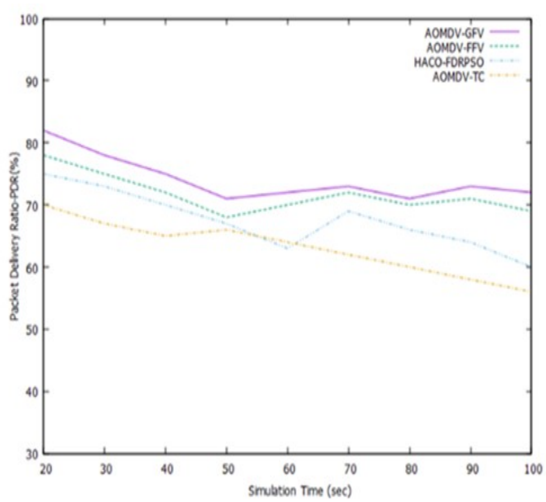

Figure. 4: Node Count Vs PDR (%)

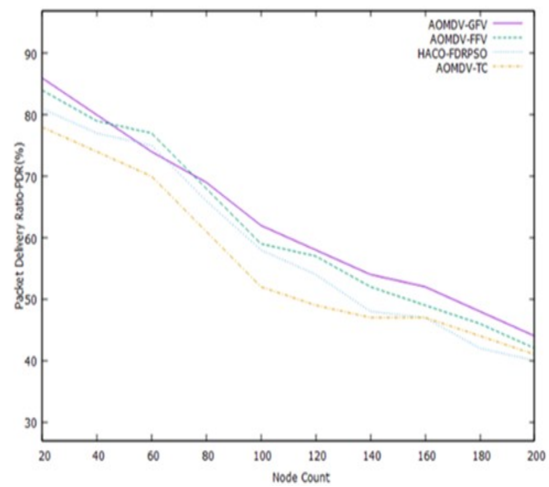

Figure. 5: Simulation Time Vs PDR (%)

8.2 Throughput:

Throughput is determined with different node counts, node mobility speed, simulation time, and packet loss rate. Figure 6 shows a comparison with different node counts and throughput values. Increased node count will result in heavy traffic which leads to collisions between the nodes. While compared to other protocols the proposed one has less congestion due to optimal path selection.

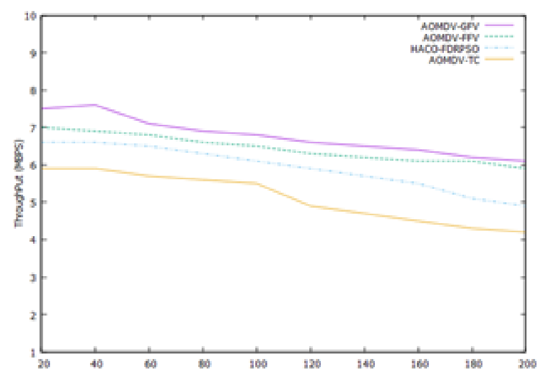

Figure. 6: Node Count Vs Throughput

Figure 7 shows a comparison of various nodes and node mobility speed. The proposed protocol chooses the more stable path preferably the nodes having low mobility with low speed. The other unstable paths are discarded by the suggested protocol. Compared to other protocols the proposed achieves better outcomes

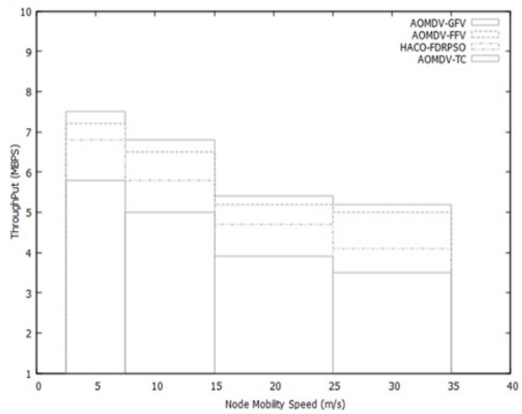

Figure. 7: Node Mobility Speed Vs Throughput

Figure 8 shows the comparison with packet loss rate which is calculated in terms of total packets sent and received. More packet loss will be caused by the lower energy of a node, node mobility speed, and collisions between the nodes. The proposed protocols AOMDV-GFV and AOMDV-FFV perform good while compared to other HACO-FDRPSO and AOMDV-TC protocols due to path selection being done based on the number of collisions being less in the network.

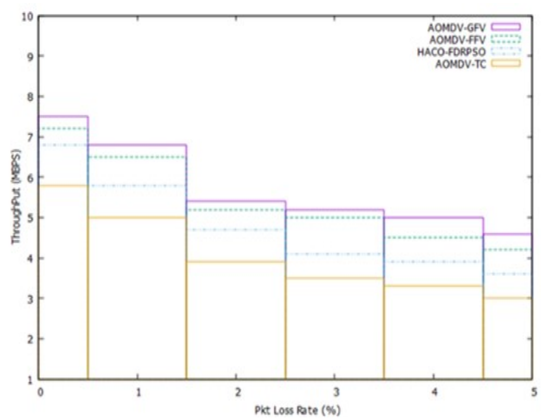

Figure. 8: Pkt Loss Rate Vs Throughput

Figure 9 shows how throughput is achieved in various simulation times. The proposed algorithm shows better thought when compared to others because of choosing stable links in the route and less congestion in the traffic

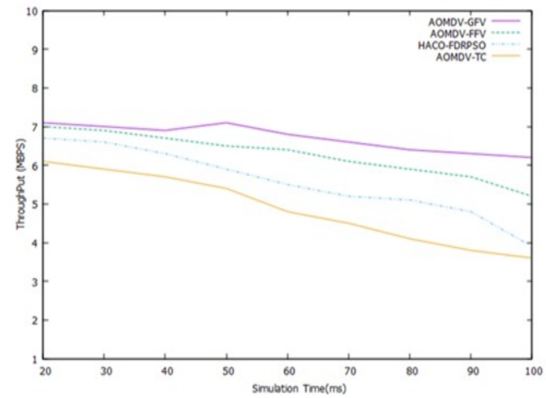

Figure. 9: Simulation Time Vs Throughput

8.3 End-to-End Delay:

Figure 10 shows the comparison made with the number of nodes with their delay. As node count increases in the network, the congestion also increases due to more traffic this results in a large number of packet retransmissions and requires more time to find the optimal route. The proposed protocol achieves less delay while the nodes are increasing which results in lower retransmissions compared to other protocols

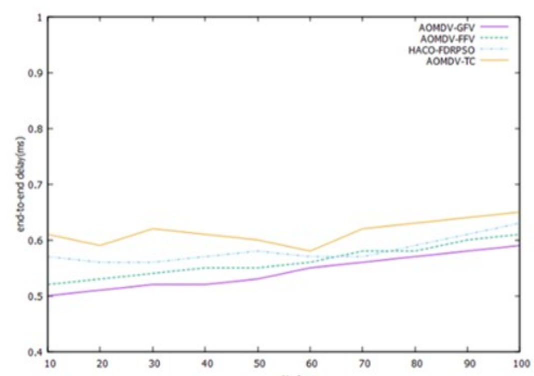

Figure. 10: Nodes Vs EED

8.4 Energy Consumption:

Figure 11 shows the results of all mentioned protocols compared with different node counts. If the nodes are more in the network the computing time will get higher resulting in more energy consumption but in our proposed protocol the consumption of energy was minimal due to fewer packet retransmissions i.e. route selection was done based on the less congestion leads to improvement in entire network outcome.

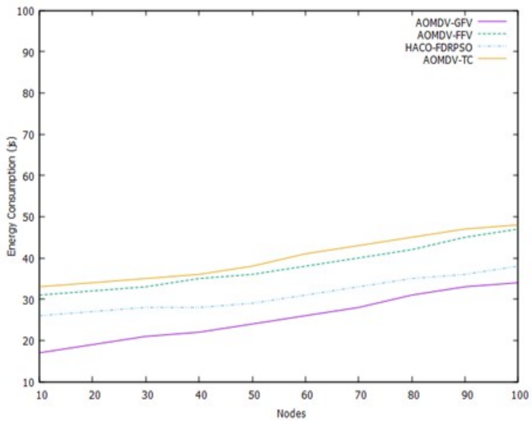

Figure. 11: Nodes vs Energy Consumption

9. CONCLUSION

In an adhoc wireless network, as the network grows with a large number of nodes with greater mobility speed the collision between the nodes will get higher which results in more number packet loss, and also due to unstable links more number of retransmissions will get more result in higher energy consumption. In this paper, we used the AOMDV protocol to find the numerous feasible paths to the destinations and then we utilized the CSMA/CA protocol to identify the collisions in all feasible routes. The suggested procedure makes an estimate of the path's congestion and link stability. Out of all the paths that were possible, we had chosen the best one using fitness values and a genetic algorithm. The simulation outcome shows that our proposed protocol achieves superior results correlated to other w.r.t. throughput, packet delivery ratio, delay, and energy consumption.

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