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Energy Aware Routing through Genetic Algorithm and AOMDV in MANET

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Abstract: A MANET is an accumulation of different radioed-on-the-air hardware devices connected together temporarily based on the transmission range in the absence of any framework. Energy is the major factor to utilize efficiently to enlarge the longevity of the network as a result, nodes contain mobility that cannot provide continuous energy. Each mobile node will get energy from the power unit which will be depleted in a short time due to the movement of a node, Continuous transmissions, and finding the path. Also heavy loss of data while transmission because of collisions in the network. Heavy loss of data will result in slowing down the packet delivery during the transmission. Here we render the serious problems in the infrastructure-less wireless network. We proposed a new optimized Genetic Algorithm(GA) with the assistance of suitable methods i.e. FF to procure the optimum route against all the possible multiple routes with the help of Ad-hoc On Demand Multi Path Distance Vector routing protocol (AOMDV). We also merged with optimized Genetic Algorithm with one of the finest multi-path routing protocols named GA-AOMDV. These techniques are furnished to select the optimum path in accordance with the distance between the wireless devices i.e. shortest path, high fitness value, congestion in the network, and utilization of the energy. The performance of the suggested technique was collated with the other suitable protocols.

Keywords: *Genetic Algorithm, shortest path, optimal route, Fitness value, congestion, and energy*

1. Introduction

A MANET (Mobile Ad hoc Network) is a wireless network a certain doesn't have a bit of infrastructure to communicate the mobile nodes with each other. The communication between the nodes was done through the wireless medium. It is an individual aligning and individual building the wireless system that results in changing the topology of the network very frequently. It was mainly used in large areas with high volume and current multi-media applications such as Marketing and Advertising, Entertainment, banking sectors, video conferencing, and various graphical design tools. In MANET, every single mobile node will act as a host as well as a router. To gain access to multimedia applications the ad-hoc wireless network needs more energy with less traffic and high quality of service resources. To sustain the network a huge energy was required for every mobile node. In general, the energy was operated in the form of batteries which was scarce in the wireless system [1]. While being a consequence, a well-structured and efficient utilization of the energy of every mobile node also escalates the longevity of the system [2]. Several algorithms and procedures in the MANET will compute the path in accordance with the minimum amount of links, minimum battery usage together with congestion due to traffic [3].

Few power reduction routing protocols will control the consumption of energy for every mobile node. The objective of these routing protocols is to select the best route which consumes minimum energy which leads to an increase in the lifespan of the network [4]. Furthermore, the heavy congestion in the network exhausts more amount of energy which will affect the good outcome of the system and also drop information.

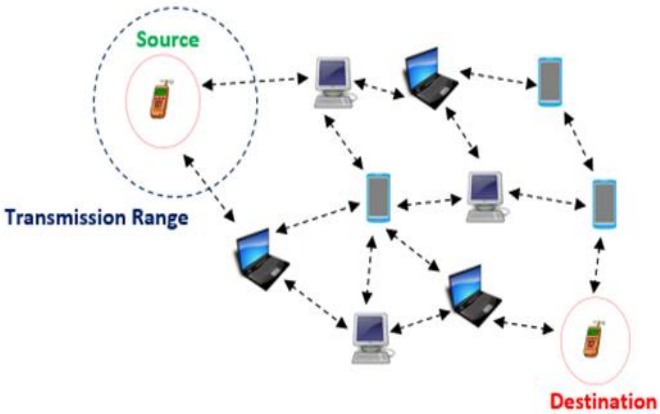

Fig 1: Connecting devices in a mobile ad-hoc network

Figure 1 shows that various wireless devices are connected to each other based on their transmission range and these devices have the ability to move from one location to another leading to alter the arrangement of nodes in the system frequently [5]. Multi-path ad-hoc routing protocols such as AODV and DSR are used to determine the multiple feasible routes from the origin node to the sink node. This routing selection process will reduce the delay and also helps when the nodes have link failure.

To enhance the notable serious issues, we applied a Fitness Function(FF) merged with an enhanced approach to evaluate the

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optimum path originating at the origin node directed towards the sink node as a consequence of a multi-path routing protocol named AOMDV. On the other hand, we proposed an optimized genetic algorithm blended with the AOMDV multi-path protocol (optimized GA-AOMDV) based on the Fitness Function. The FF will choose the best path by considering various factors in the network. The chosen best route should have the shortest path originating at the origin node to the endmost target node along minimal battery depletion and the selected route should contain low traffic to keep away from the collisions in the ad-hoc wireless network. To keep away from the traffic, we used TCP Congestion Control mechanisms [6] in the fitness function.

2. Literature Review

Chen et al. [9] developed an energy ware reserved queue size protocol named AOMDV-EC based on the queue length. The suggested above concentrated on how to balance the load and consumption 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. [10] proposed a protocol in accordance with an adaptive heuristic algorithm that will select the optimal route between the mobile nodes by means of operations called alteration and cross-over functions. The final route selection was made by comparing the energy utilized and the distance of connecting nodes.

Madhvi Saxena et al. [11] suggested a routing algorithm known as MO-AOMDV based on multiple objectives. The path selection will be made on node quality and connectivity links. Here every node maintains statistics with respect to the remaining battery of every single neighboring node. Shah et al. [12] suggested an adaptive procedural algorithm using the base of bio inspired genetic algorithm to choose the optimal links to the target node. By considering the appropriate values of every link the final path selection was made which gives better performance to the network.

Saleh A, Alghamdi [13] introduced a protocol to distribute the load in accordance with the utmost and least values of unused energy in an 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 [14] presented a genetic algorithm(GA-CARP) to deplete the blockage in the route. They used chromosomes (temporary paths) and genes as parameters to deplete the blockage in the system by performing cross-over and mutation operations. A Deshpande [15] proposed a hybrid AOCSD-GA protocol to console the congestion and upgrade the TCP performance in the network. By using an elitism approach the routes are chosen in a random manner after completing the prediction of congestion. The metrics delay, latency and hop count are availed to judge the functioning of the network system.

S Sathya et al. [16] 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. [17] suggested a routing scheme named ERL-AOMDV in order to conduct inquiry more extensively than the leftover battery of nodes. The protocol analyses both the remaining lifespan of a mobile node and the estimated total time in a system to select the best path.

Mahmoud M et al. [18] suggested an altered battery depletion scheme using AOMDV. The route selection is done by considering the energy parameter on behalf of counting the number of links to reduce the battery consumption and enlarge the longevity of the network. While choosing the path the mobile devices who having low power will be rejected.

Bhavna S et al. [19] recommended a scheme named as E-AOMDV. 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 present battery level of the node to select the node for transmission in the network. Lu G and Peng Li [20] designed a routing scheme by balancing the payload 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. [21] presented an AGEN-AODV routing protocol for heterogeneous wireless networks. The routes are selected in accordance with 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. [22] suggested to use 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. [23] presented a routing scheme i.e. GAER emanate from 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 increase the functioning of the network.

N Papanna et al. [24] suggested a multicast route approach (EELAM) using an adaptive genetic algorithm. The proposed scheme deals on the tree arrangement of the nodes in the system to choose the neighbor nodes that have high residual energy and low batter usage. Farsi M et al. [25] designed a traffic-aware assembled routing algorithm to minimize the traffic problems in the system. For picking the route from the network the main cluster head and secondary cluster head had used to decrease the flow of data and increase the lifespan of the network.

3. Proposed Method

In the AOMDV routing protocol [7] the origin mobile node will transmit a control packet called Route Request(RREQ) in the wireless network to compute all the feasible paths to the sink mobile node. From the feasible paths, the above routing protocol chooses the optimal path by considering the shortest distance i.e. number of leaps uniting the origin and the sink mobile node. By considering the link selection, we proposed an optimized genetic algorithm(GA) merged with AOMDV using a fitness function called GA-AOMDV. In the proposed algorithm when the RREQ control packet was transmitted to the network, the origin node had to choose the optimal path from the numerous paths in accordance with shortest distance, less congestion, and minimal consumption of energy.

The fitness function will compute the suitable value for every possible path or link to the final node. The essential requirements to compute fitness value are a) a number of hops b) the remaining battery level of every node in the route and last one c) congestion should be less.

4. Fitness Function (FF)

To compute the Remaining Energy(R_e) for the mobile node the formula is as follows:

$$R_e = {R_{en}}/{R_{an}} \qquad (1)$$

Where R_e is the complete remaining energy of the fitness function. R_{en} is the remaining energy of each node and R_{an} denotes total remaining energy of all nodes.

To compute the number of hops i.e. the distance between the nodes(S_{dist}) the formula is as follows:

$$S_{dist} = {Dist_{nn}}/{Dist_{sd}} \qquad (2)$$

Where S_{dist} is the fitness value of the distance among nodes, $Dist_{nn}$ one node to other node distance and $Dist_{sd}$ is the overall distance from the origin to target node.

To calculate the congestion in the route we use the TCP mechanism.

$$QL = (TT - ST) * BW \qquad (3)$$

Where QL is the length of the queue which is dynamic and it will update based on the TT time. The value of QL is used to measure the traffic position on the route. ST denotes the minimum value of TT identified by the TCP.

The Threshold values of dynamic Queue Length(QL) is calculated as:

$$T_h = C * TL_{max} \qquad (4)$$

Where TL_{max} denotes the maximum value of queue length identified by the sender and C is a constant value ranging between 0 and 1.

By comparing Queue Length(QL) and Threshold value(T_h), we can say the status of traffic in every route. If $QL \leq T_h$, the traffic on the route is much less compared to other possible routes which we can select as an optimal route even though it has few arbitrary packet drops. On the other hand, if $QL > T_h$ the traffic on the route is very high and leads to a massive drop of packets in that route which will affect the overall throughput in the network.

From the values of R_e, $S_{dist,}$ and T_h we can compute the FF as follows:

$$FF = R_e + S_{dist} + C_r \qquad (5)$$

The FF value will determine every possible route originating out of the origin to the final mobile node. The preferred link will be chosen by the proposed optimization algorithm (GA-AOMDV) with the help of FF value which is shown in the algorithm1.

5. Methodology

The working flow of the suggested algorithm is shown in Figure 2. In phase 1, determining the multiple routes from the origin node to the final node using AOMDV protocol, computing the congestion of every route by using equation 3 and the Fitness value will calculate for every route by using equation 5.

In the Next Phase, the procedure for the optimized genetic algorithm was initialized in four steps: Configure the framework, Cross-Over, Alteration, and Choosing the final route. Step 1, While creating the wireless network, beginning itself we have to assign the parameter values which are shown in algorithm 2. Next Step 2, Applying Cross Over function i.e. two selected routes are paired up with the probability Cp of 0.5, selection of the route will be made with fitness values whose route having higher and it will be swapped to another possible route. Step 3 after cross over each route will undergo to change in the sequence of the nodes and repeats the cross-over operation with different probability(Cm). The final step in the algorithm is to choose the path which has the highest fitness value ccompared to all other possible routes.

Algorithm 1: Optimized GA-AOMDV

Input: All possible routes

Output: Optimal Route Selection

1. Initialize M_p = 0.1 and C_p = 0.5
2. Read FF = Fitness_Function( )
3. PoR = Possible Routes from S to D
4. Farr[ ] = none;
5. C_n = 0, C_o = 0;
6. Begin
7. For Each Route in PoR
8. While (FP(PoR) = NP_r)
    F_CrossOver(C_p,NP_r,OP_r) = C_n
9. F_Mutation(M_p,ch,N_p) = C_n
10. F_Function(Group of C_n) =F_{nc}
11. End While
12. For Each Route in F_{nc}
    If (F_{oc} < F_{nc}) then
    Farr[ ] = F_{nc}
    End if
13. End for
14. End for
15. Return_Value Farr[ ]
16. End

In Algorithm 1, the Cp and Cm are probabilities of cross-over and mutation. Farr[ ] is an array that contains the fitness values of every route arranged in decreasing order. PoR is defined as all possible routes originating at the origin to the sink determined by the routing protocol. The latest highest fitness value is stored in the NPr and old fitness values is stored in OPr. The Foc and Fnc fitness values of NPr and OPr.

Algorithm 2: Computing the Fitness Value

Input: All Feasible routes from Algorithm 1

Output: FF values of Every Route

1. Begin Procedure Fitness Function (FF):
2. Initialize X to zero;
3. While (X≤ Y) do
4. R_e = equation (1)
5. S_{dist} = equation (2)
6. if (BQL > T_h) then
7. C_r(i) = 0;
8. else
9. C_r(i) = (BF-BQL) / BF;
10. endif;
11. FF = equation (4)
12. Increment Y;
13. return FF;
14. end while;
15. End Procedure;

6. Simulation & Parameters

Numerous specifications are used to measure the interpretation of the proposed methods in accordance with the fitness formula. The values of specifications are indicated in Table 1. The performance of the suggested scheme is computed in various specifications such as Throughput, Packet Discharge Ratio, End-to-End delay(EED), and Energy Consumption(EC).

A. ***Throughput:*** used to evaluate the behavior and character of the networks in terms of packets delivered successfully to the final node.

$$\text{Throughput}(\%) = \frac{\text{Amount of bits Received}}{\text{Total Time taken in Seconds}} \quad (6)$$

B. ***Packet Delivery Ratio (%):*** The proportion of the count of datagram reached to the sink and the count of datagram dispatched from the origin node. PDR (%) is computed as follows:

$$\text{PDR}(\%) = \frac{\text{Amount of pkts delivered}}{\text{Amount of pkts sent}} \quad (7)$$

C. ***End-to-End Delay (EED):*** The proportion of time spent by the datagram to arrive the final node from the origin node. EED is computed as follows:

$$ED = T_d + P_d + Q_d + PS_d \quad (8)$$

Where T_d is the Delay during the transmission, P_d denotes the delay in the propagation, Q_d is the Time spent in the queue and PS_d is the Processing delay.

D. ***Energy Consumption(EC):*** Used to compute, how much energy was utilized for the transmission of packets in the system throughout the transmission period and is computed as follows:

$$C = \sum(I_e - R_e) \quad (9)$$

Where Ie is the energy that was assigned in the beginning of the transmission and Re is the remaining energy after completion of the transmission during the simulation period.

Type of the Parameter	Specification Values
Simulator	NS 2.34
Dimensions of X & Y	750 m X 750 m
Transmission_Time	100 sec
Nodes	20,40,60,80,100
Channel	Wireless
Node Mobility Max Speed	10 m/s
Cross Over (C_p)	0.6
Mutation (M_p)	0.1
Initial_Energy	150 J
Antenna Propagation Type	Random Way Point Mobility
MAC Protocol	IEEE 802.11
Traffic_Type	UDP, cbr
Transmission Range	300M
Protocols Used	AODV, AOMDV, AOMDV-FF

Table 1: Parameters for Simulation

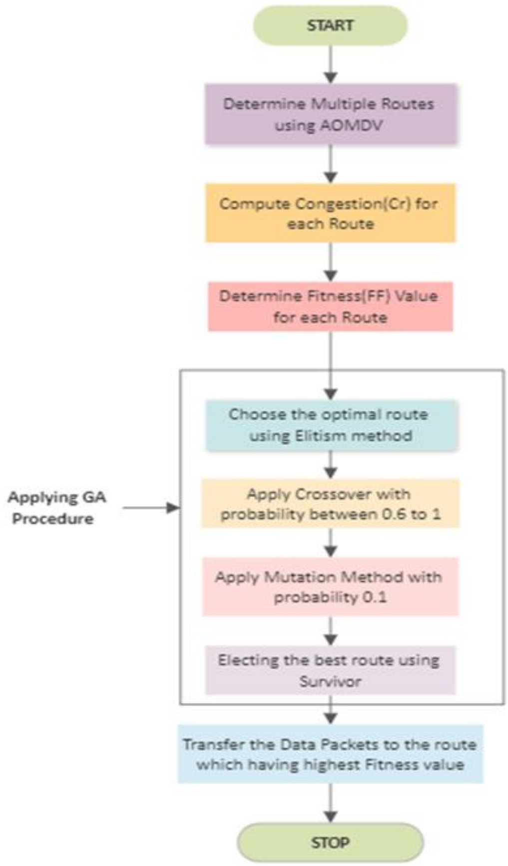

Fig 2: GA-AOMDV Flow Chart

7. Results

7.1. Throughput

Figure 3 shows the throughput of four protocols obtained from the simulation by varying the range of nodes. The recommended optimized GA-AOMDV protocol showed higher results compared to other protocols due to the usage of TCP congestion in each route which the nodes will stay away from the traffic and the choice of the shortest path in accordance with the minimal consumption of energy.

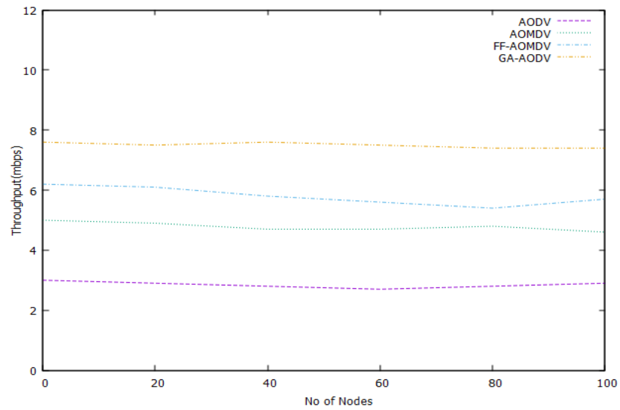

Fig 3: Throughput(Efficiency) vs Degree of Nodes

Figure 4 says the results of all protocols by differing the simulation time with efficiency. When the transmission time is extended the congestion in the system will be increased. The count of dropped packets will get increased. Out of all other protocols, the proposed one achieves high throughput due to the usage of the traffic control approach.

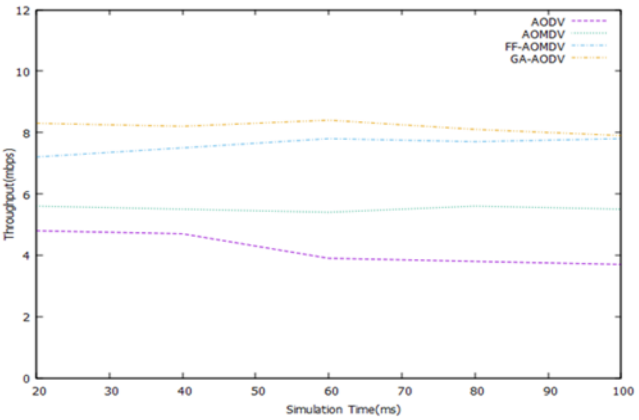

Fig 4: Throughput vs Simulation Time

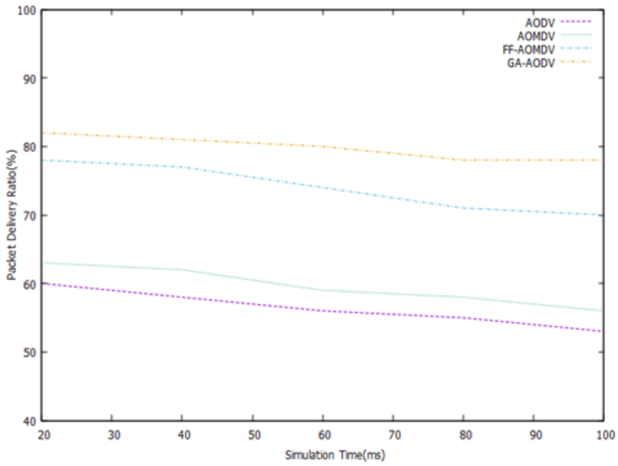

Fig 7: Packet Delivery Ratio (%) vs Simulation Time

7.2 Packet Delivery Ratio (%)

Figure 5 exhibits the results of all the mentioned protocols by varying the speed of the mobile node. When the movement of the node is low, each and every protocol got higher throughput. The proposed protocol GA-AOMDV at a speed of node 20 m/sec achieved high throughput while the other protocols achieve less caused by periodic changes in the network. By considering these results we can say that our proposed protocol will perform better even with topology changes.

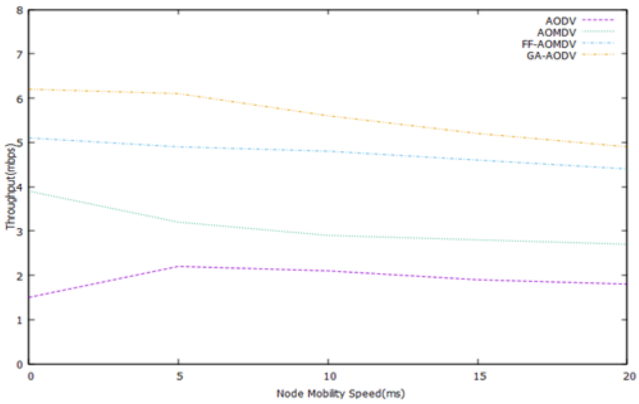

Fig 5: Throughput vs Node Mobility

Figure 6 and Figure 7 exhibit the results of packet delivery Although the node mobility is at 20 m/sec by varying the degree of nodes. when the degree of nodes increases in the network with simulation time there is a chance to get more collisions in the network resulting to heavy packet loss. In the proposed protocol we had taken care to avoid the congestion with the help of the fitness function resulting in less packet loss compared to others.

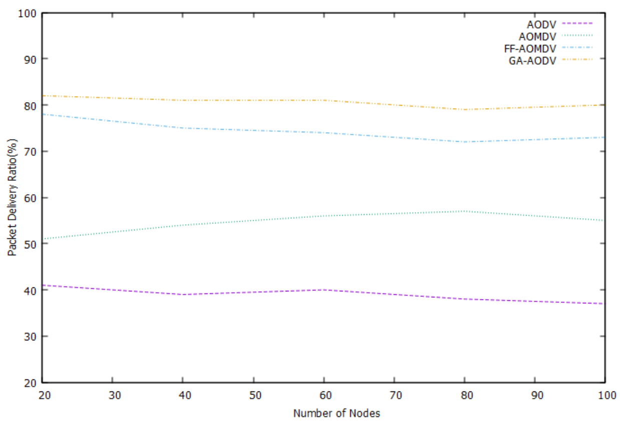

Fig 6: Packet Delivery Ratio Vs Degree of Nodes

7.3 End–to–End Delay(e2e)

Figure 8 & Figure 9 exhibit the analysis of the delay between the nodes for different protocols. The proposed protocol operates on multiple parameters such as a minimal number of hops and lower consumption of energy which in turn is utilized to choose the optimal path between the origin node to final node. The other primary protocols will select the optimal path based on only one parameter i.e. the number of hops this results in less delay between the nodes.

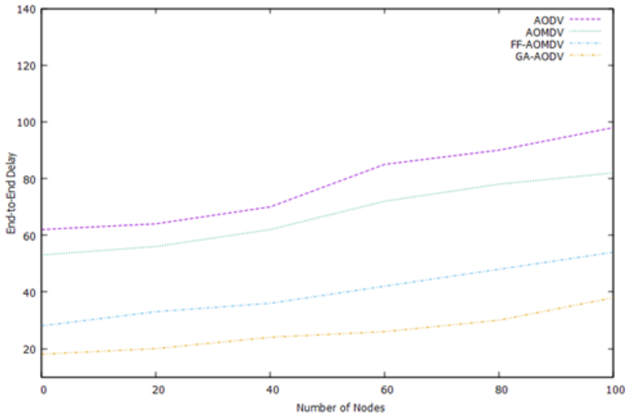

Fig 8: E-to-E Delay vs Degree of Nodes

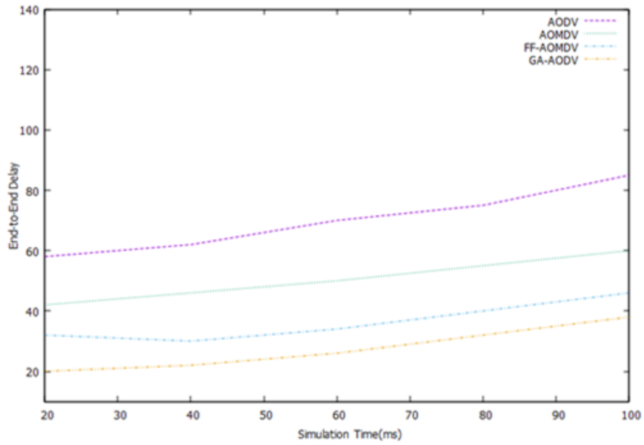

Fig 9: E-to-E Delay vs Simulation Time

In Figures 8 & 9 when the degree of nodes is less and the transmission time is very low all the protocols achieve good results but at the same time that the degree of nodes getting larger with simulation time the lag of other protocols is high which decade the system performance. The suggested scheme performs the operations such as mutation and cross-over not to groove the delay. The final step, survivor selection will take less computing time due to the less number of available routes after performing cross-over and mutation.

7.4 Energy Consumption

The outcome of the consumed energy in the entire system by varying the degree of nodes and simulation time was exhibited in Figure 10 & Figure 11. The principle objective of the suggested protocol is energy-saving during transmission. Our proposed optimized GA-AOMDV showed superior outcomes compared to other protocols. In MANET, during the datagram transmission to the target node, computing the optimal linked energy of the mobile node is depleted in a high manner.

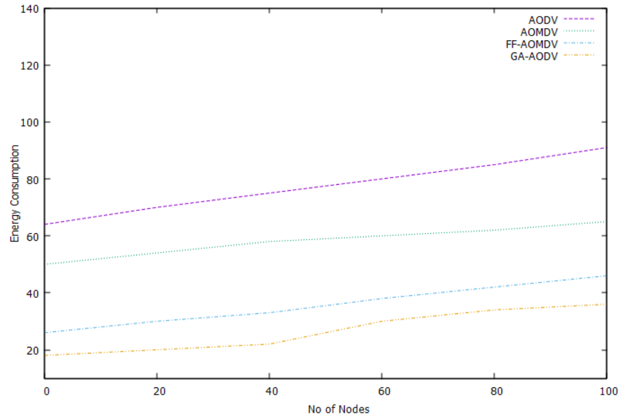

Fig 10: Consumed Energy Vs Degree of Nodes

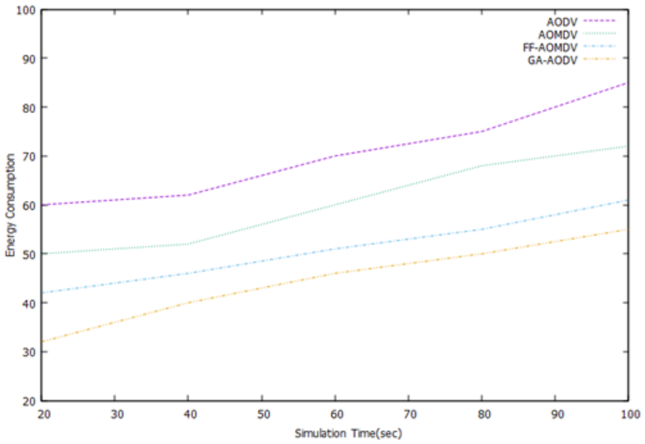

Fig 11: Consumed Energy Vs Simulation Time

8. Conclusion

In MANET, due to the mobility of nodes, the number of connection failures was high throughout the transmission and escorted to a bigger packet drop which in turn, re-sending the dropped packets to the node will utilize more amount of energy. In the proposed approach we utilized the concept of fitting the suitable values to compute the optimum route originating at the start node to the sink based on the minimal count of hops, bottleneck control, and utilization of the battery. To reduce the traffic in the network we used TCP control procedure. The combination of FF and optimized GA-AOMDV protocol chooses the optimal route between the origin node and final node from the feasible routes in the ad-hoc wireless network. In our experimental results, the proposed method gives better throughput and general loss of packets compared to other existing protocols and also a smaller amount of delay between the nodes. This makes better network performance and utilizes the energy in an efficient manner which in turn increases the network lifespan.

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