Modified AODV Using Genetic Algorithm to Minimize Energy Consumption in MANET

Veena Trivedi, Padmalaya Nayak

Abstract: Routing is one of the most challenging tasks in Mobile Ad hoc Networks (MANETs) as the network is resource constrained and dynamic by nature. Ad hoc infrastructure along with node mobility further makes the network more challenging and unstable. Limited radio range communication, dynamic topology makes the routing technique even more fuzzy to find a desired path from source to destination. Many studies provide many different solutions to route the data from source to the destination. Ad hoc On demand distance vector (AODV) routing protocol is one of the most effectual reactive routing protocols to handle the uncertainty of routing path in MANET. In this paper, a Genetic Algorithm based new protocol is proposed to find the forward path from source to destination. But, the same principle of AODV is applied for back word path. Genetic algorithm has been applied to solve many optimization problems in the literature. The proposed protocol uses the potentiality of genetic algorithms to resume a path that consumes minimum energy as well as preserves a shortest routing path from source to destination. The proposed protocol is experimented and proved through NS-2 Simulator. Simulation results show that proposed protocol over performs existing AODV protocol in terms of end to end delay, throughput and lifetime.

***Index Terms*: MANET, AODV, Genetic Algorithm (GA)**

I. INTRODUCTION

Mobile Ad hoc Networks (MANETs) consist of number of mobiles nodes enable the users to communicate with each other without any central coordinator. There is no permanent infrastructure is required to set up a network. So, other way it is called as an "Infrastructure less" network. These mobile devices are self-organized to communicate with each other for sharing the data without any fixed controller. These networks have been used in diversified applications that ranges from military, defense, health care to small classroom coaching even though these devices are resource constrained. The devices in the network are closely connected and data reaches at the destination in a multi hop fashion. These nodes cooperate with each other to dynamically establish the path and to maintain routing the data packets in the network. Communication between the nodes is carried out by forwarding packets using the wireless range.

The on-demand protocols normally do not consider the existing routing information but try to discover a route to some destination node only when a sending node has a request data packet addressed to the particular node. MANETs are more vulnerable to attacks when compared to other networks. Some of the features of MANET is discussed below [1].

- *Decentralized management*: MANETs do not require any centralized coordinator to manage the network. This decentralized arrangement leads to many challenging issues related to traffic monitoring with dynamic topology.
- *Resource availability*: The major problem in MANET is that all the devices are battery powered and deployed mostly in an open environment. Topology changes frequently proportional to the node's mobility. All these limited parameters within the radio range communication is highly challenging task.
- *Network size*: Scalability issue must be handled in MANET due to frequent change topology due to the node's mobility. So, the designer has to take care of these issues while developing the routing protocols.
- *Compliance amidst nodes*: Routing algorithms in MANET usually consider that nodes are cooperative and non-malignant. As a result, any attacker takes the opportunity and start behaving as a valid routing agent thus disturbs the network operation by deviating from the protocol specifications
- *Dynamic topology*: Due to the node's mobility, topology changes very frequently in MANET. It has huge impact on MANET that brings a huge impact on routing protocols
- *Confined power supply*: All the nodes in MANET consider constrained power supply, that tends to create many problems. A node in a MANET may behave in a selfish manner when it finds that there is power supply restrictions.

Routing in MANETS has been always an open issue [1]. An optimized routing algorithm helps to generate a better routing table.

Hence MANETs have been integrated with machine learning techniques such as fuzzy logic Genetic algorithms, Neural Networks etc. The basic architecture of the MANET is given in Figure 1. Rest of the paper is framed as follows. Section II outlines the existing work. Section III presents the

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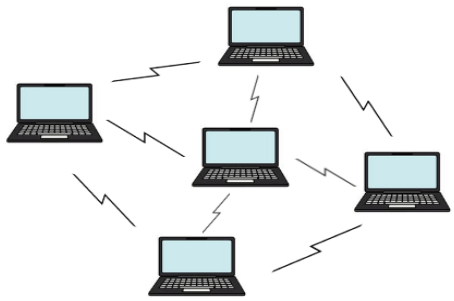
proposed algorithm. Results and discussions are given in Section IV followed by a conclusion in Section V.



II. RELATED WORKS

This section discusses few existing routing protocols for MANET available in the current literature. MANETs have been always in an interesting topic of research and has opened many challenging issues for research. The nodes in the MANET are neither fixed nor permanent that makes topology change dynamically and frequent link failures [2]. The nodes in MANET are battery operated and have limited lifetime which must be optimized for longer operational characteristics of the nodes. The routes must be optimized, and better routing techniques should be proposed. Therefore, providing an efficient and effective routing in MANETs with limited resources like radio communication, limited bandwidth and limited power is a challenging task. The author in [4] have proposed an energy efficient, cross layer design paradigm making use of nonlinear programming formulation for routing and traffic scheduling. In [5], an adaptive HELLO messaging scheme is proposed which aggregates the local link connectivity information that keeps the track of the link status between nodes making use of AODV protocol to minimize the energy consumption of mobile nodes. In [6], the author has developed dynamic AODV back up routing protocol (DABR) to enhance the routing mechanism in dense MANET. Many researchers have focused on many soft computing techniques like Neural Networks, Fuzzy Logic, Genetic Algorithms for optimization purpose. In this paper, we have focused on some GA based techniques as our work is based on GA based routing. In primary phase, GA is applied to discover the routes and some techniques are used to select back up path. The basic capability of Genetic algorithms and the chromosome generation mechanism using meta heuristic technique and a good designed objective function paves a way for optimization in each network scenario. Related to this, in [3] the author has used Genetic algorithms to optimize both distance and congestion factor. In [7-8] energy drain rate, Interference, congestion status are used to compute the path evaluation function. The authors in [11] discuss a genetic algorithm that generates the k shortest paths using bandwidth constraints for multipath routing.

Many research papers discuss about the optimization of the routing protocol in MANETs. The optimization aspect considered in this paper is related to energy present at the mobile nodes. The authors in [13-14] have also emphasized on link cost management and its optimization and have incorporated genetic algorithm features to increase the reliability of the network. In another paper [14] an improved Genetic Algorithm has been proposed which aims at optimizing the network link cost, thereby increasing the reliability of the network by reducing link media costs. This paper has implemented the algorithm in a restricted environment of maximum N nodes and to extend it for a wider network domain. The paper considers the congestion condition which occurs in the network due to heavy flow of traffic. This work also shows the impact of congestion control to an extend but proposes an enhancement for integrating the parameters of congestion with optimization. Motivated by this fact, an algorithm is proposed in this paper that considers both the distance and energy to define the objective function. The efficiency of the proposed protocol is shown in Section 4.

III. PROPOSED ALGORITHM

Consider a Network environment with N mobile nodes and these nodes are close to each other within the radio communication range. All these nodes are available in the same transmission range of each other. All mobile nodes are equally capable to receive and transmit the packets from each other. The proposed algorithm uses the Genetic Algorithm approach to route the data packet from to the destination. It calculates a fitness function to find the neighbor node, uses crossover and mutation mechanism for creating the new paths (new chromosomes). The basic model of GA is given in Fig. 2.

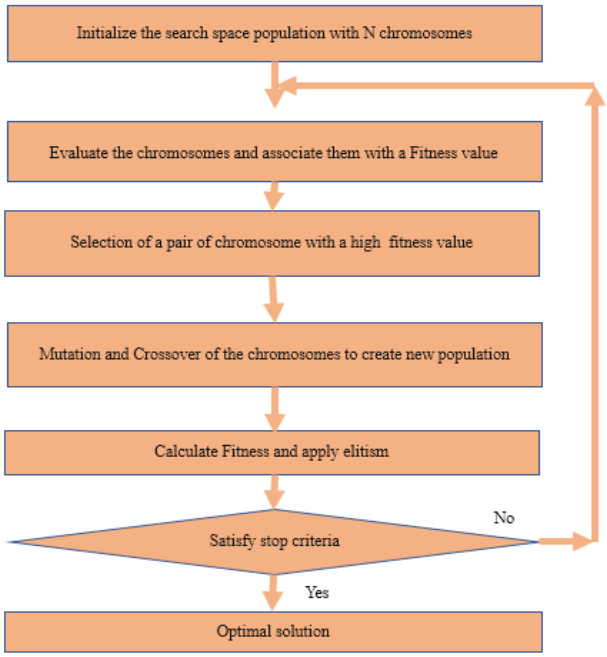


Fig 2: General Principle of Genetic Algorithm

A. Network Assumption

In the proposed system architecture, the mobile nodes are positioned randomly to form a network for certain applications. The proposed model is shown in Fig 3.

1. The network consists of mobile nodes and each node is characterized by a unique Identification number.
2. The MANET environment is homogeneous type with all mobile nodes having equal initial energy.
3. The number of mobile nodes is application dependent and is assumed as N.
4. The nodes are considered to have mobility characteristics and hence distance between the nodes keeps on varying.
5. The distance and the residual energy is considered for calculating a new path between the source and destination.

B. Network Architecture

The proposed model of MANET is shown in Fig. 3. Initially we have considered 7 nodes to validate the proposed model. Then, we have experimented with 25 nodes and finally concluded with 50 nodes.

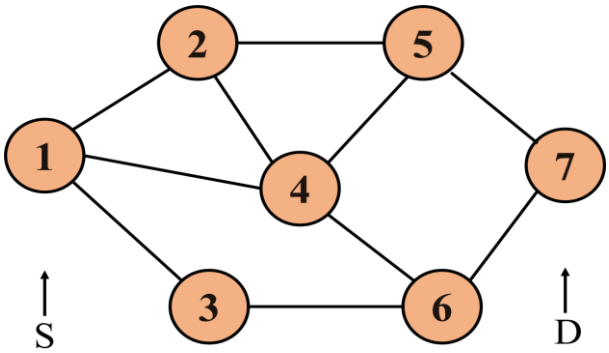


Figure 3: Example of Proposed Topology

Let us consider a MANET of number of nodes N that can be represented as a graph of G (V, E) where the |V| is the set of nodes and |E| is the set of links. For a graph with |V| vertices, the adjacency matrix is a |V| X |V| of 0's and 1's where the entry in row i and j column is 1 only if there is an edge between (i, j) otherwise it is 0. The adjacency matrix of the proposed model is given in Fig. 4. Here, 7 vertices in network graph is identified by set of numbers not by names.

	1	2	3	4	5	6	7
1	0	1	1	1	0	0	0
2	1	0	0	1	1	0	0
3	1	0	0	0	0	1	0
4	1	1	0	0	1	1	0
5	0	1	0	1	0	0	1
6	0	0	1	1	1	0	1
7	0	0	0	0	1	1	0

Fig. 4: Adjacency Matrix of proposed topology in fig.3

C. Genetic Algorithm Based AODV

GA is considered as a robust technique to search an optimal path from source to destination. In our proposed model, we have used the basic principle of Genetic Algorithm. The main aim of this proposed protocol is to provide a shortest path applying GA principle for a Mobile Ad hoc Network so that it can consume less energy and prolong the network lifetime.

➢ **Terminologies Used**

- A path from source to destination represents individual population
- An adjacent node corresponding to a node represents as child
- An entire path from source to destination indicates a chromosome
- A string of adjacent nodes identifies a gene
- All the possible paths from source to the destination implies chromosome structure

➢ **Procedure for GA based AODV**

Step 1: Initial Population: Consider N number of nodes in a network

Step 2: Initialize all the nodes

Step 3: The neighbor node is selected based on Fitness function. The Fitness function can be calculated as follows

$$F_t = F_r + F_d \quad (1)$$

Where,

F_t = Fitness function of each node (depends on residual energy and distance)

F_r = Fitness function based on energy

F_d = Fitness function of a node based on distance

F_r and F_d is calculated using the formula given in equation 2 and equation 3.

$$F_r = \frac{E_g}{E_T} \quad (2)$$

E_g = Residual Energy at each node

E_T = Residual Energy of all the nodes

$$F_d = \frac{D_{n\_n}}{D_T} \quad (3)$$

$D_{n,n}$ = Distance between node to node
D_T = Total distance from source to Destination

Step 4: Apply Crossover and Mutation operators are applied in-order to generate the set of paths to the destination

Step 5: GA is applied with fitness function till a complete path is found. Its stops when all the nodes run out of battery.

Example: From Fig. 3 the procedure is as follows:
1st Chromosome: 1st Path: 1-2-4-5-7

2nd Chromosome: 2nd Path: 1-4-6-7
3rd Chromosome: 3rd Path: 1-3-6-7
After **Crossover** of 1st and 2nd Chromosome
4th Chromosome: 1-4-5-7
After **Mutation**: 1-2-5-7
The process continues till it satisfies the stopping criteria.

Parameters	Values
Area of Simulation	1100X600
Node Number	50
Routing protocol type	AODV
IP protocol type	UDP(CBR) Traffic
Antenna Model	Omnidirectional
Type of MAC	802.11
Transmission Speed	1.2Mbps
Bandwidth	20MHz
Security Algorithm	RC5
Data Payload	512 bytes
Wireless Channel	Two way ground propagation
Simulation Time	50 sec,100 sec, 200 Sec

IV. RESULTS AND DISCUSSION

To verify the efficiency of proposed algorithm, the network is simulated and experimented with NS-2 Simulator. The network is organized with 7 nodes initially in the grid area of 1100m X660m. Slowly, the number of nodes is increased to 25 and 50 nodes to verify the scalability of the network. Data Packet size is considered as 512 bytes. IEEE 802.11 is used in physical and data link layer. The parameters of our interest are summarized in the Table 1. The simulation was carried out on conventional AODV protocol and proposed protocol which is referred as GA-AODV. Few performance parameters like end to end delay, throughput, packet delivery ratio is considered to proof the efficiency of the proposed protocol. The result has been plotted from figure 5 to figure 9.

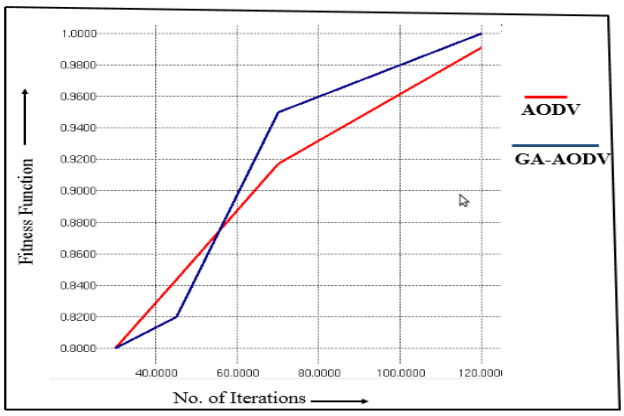


Figure 5: Fitness Function Vs. No. of Iterations

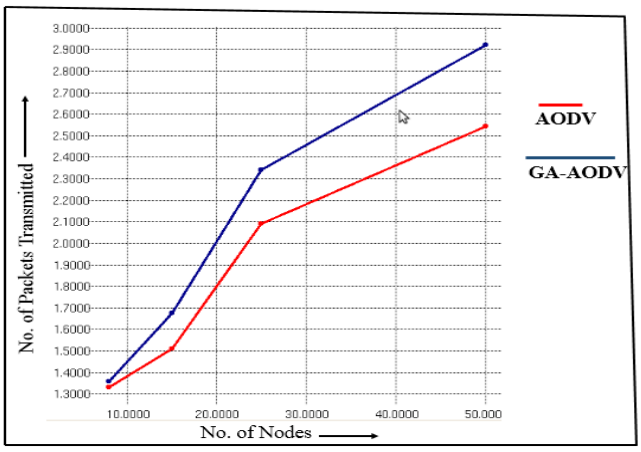


Figure 6: No. of packets transmitted Vs. No. of Nodes

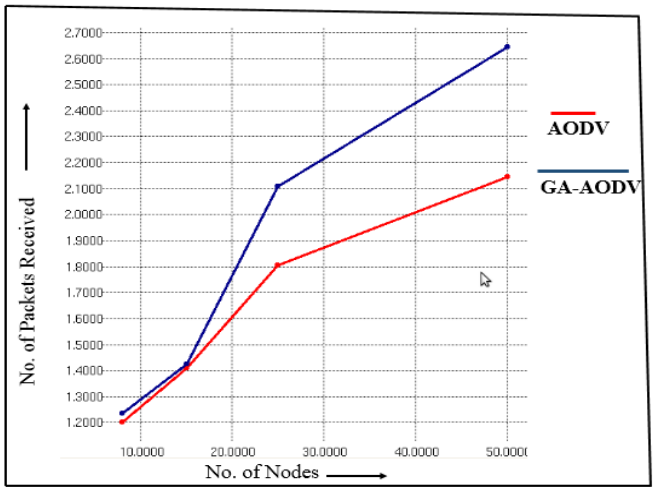


Figure 7: No. of packets received Vs. No. of Nodes

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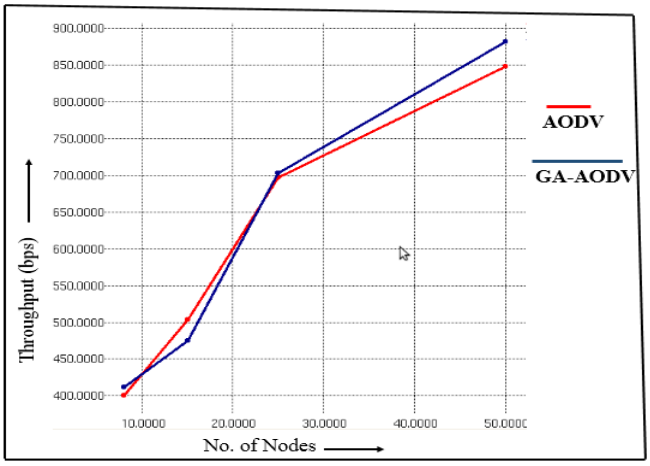

Figure 8: Throughput Vs. No. of Nodes

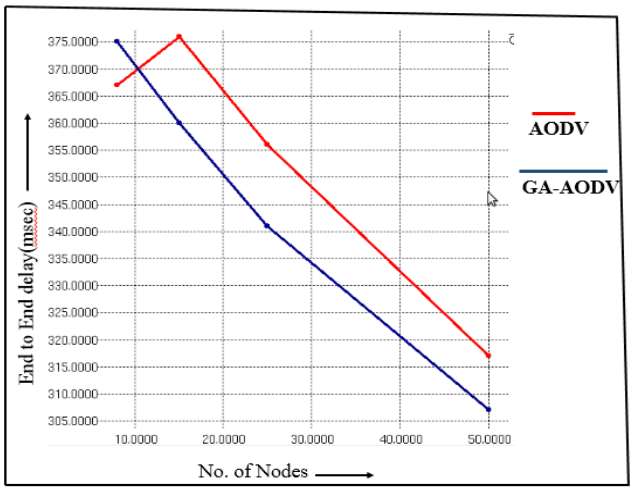

Figure 9: End to end delay Vs. No. of nodes

Figure 5 shows how the fitness function varies with respect to number of generations. The Number of iterations signifies the number of generations. It is shown from the simulation results that Genetic Algorithm based AODV protocol performs better than the basic AODV protocol. Figure 6 and 7 shows the number of packets transmitted from the source to the destination. It is seen from fig. 6 and 7 that number of packets transmitted and received is better in GA based AODV compared to basic AODV. Throughput for the two protocols is measured and plotted in figure 8. It is observed that throughput is better for proposed GA based AODD over basic AODV protocol. Figure 9 measures the end to end delay which is less in GA based AODV compared to AODV protocol.

V. CONCLUSION

This paper presents a new routing protocol that follows the principle of genetic algorithm to find the forward path in MANET and follows AODV principle for backward path routing. Genetic Algorithm is a bio inspired algorithm and is used to solve many optimization problems. It does not consider any previous routing information to select a neighbor node and finds a path dynamically to the destination using a defined fitness function. It finds an alternative path or backup path in-order to avoid reroute discovery in case of link failure or node failure. In our proposed algorithm, we make use of genetic algorithm principle that considers crossover and mutation operations. After extensive Simulations, it is concluded that our proposed protocol outperforms AODV in terms of some performance such as number of packet transmitted and delivered, end to end delay and throughput of the network.

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