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# Genetic Algorithm based Congestion Aware Routing Protocol (GA-CARP) for Mobile Ad Hoc Networks

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**Abstract**

This paper represents a genetic algorithmic approach to the congestion aware routing problem in Mobile Ad hoc Networks. Variable-length chromosomes (strings) and their genes (parameters) are the sources for encoding the problem. The crossover operation exchanges partial chromosomes (partial routes) and the mutation operation maintains the genetic diversity of the population. The proposed congestion aware routing fitness function algorithm is capable of curing all the infeasible chromosomes with an adaptive repair function. The congestion aware fitness function gives an improved quality of solution and enhanced rate of convergence. The performance metrics throughput, packet delivery ratio and delay are taken into account for computer simulations which shows the proposed algorithm exhibits a much better quality of solution (congestion aware routing) and a much higher rate of convergence than other conventional algorithms in mobile ad hoc networks.



*Keywords:* Mobile Ad hoc Networks; Congestion Control; Genetic Algorithm; Fitness Function.

## 1. Introduction

Mobile ad hoc network is considered as vital systems because they represent new generation wireless networks. Dynamic topology in such networks is frequent and hence all the nodes cooperatively maintain network connectivity without the aid of any fixed infrastructure. In order to support time-constrained services such as voice, video and teleconferencing an optimal path has to be computed within a very short time [1], [2]. The existing algorithms do not satisfy these types of requirements.

### *1.1. Problem Statement*

In mobile ad hoc networks (MANETs) congestion occurs with limited resources. In such networks, packet transmissions suffer from interference and fading, due to the shared wireless channel and dynamic

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topology. The network load is fraught through the transmission errors. There is an increasing demand for support of multimedia communications in MANETs, recently. Large amount of real-time traffic involves high bandwidth and it is liable to congestion. Congestion leads to packet losses and bandwidth degradation and also wastes time and energy on congestion recovery. Hence an optimized routing algorithm is needed which is aware of congestion.

## 2. Literature Review

Xinsheng Xia et al. [3] have introduced a method for cross-layer design in mobile ad hoc networks. They have used fuzzy logic system (FLS) to coordinate physical layer, datalink layer and application layer for cross-layer design. Ground speed, average delay and packets successful transmission ratio were selected as antecedents for the FLS. The output of FLS has provided adjusting factors for the AMC (Adaptive Modulation and Coding), transmission power, retransmission times and rate control decision.

R.Asokan et al. [4] were extended the scope to QoS routing procedure, to inform the source about QoS available to any destination in the wireless network. However, existing QoS routing solutions were dealt with only one or two of the QoS parameters. It was important that MANETs was provided QoS support routing, such as acceptable delay, jitter and energy in the case of multimedia and real time applications. They have proposed a QoS Dynamic Source Routing (DSR) protocol using Ant Colony Optimization (ACO) called Ant DSR (ADSR).

RamaChandran and Shanmugavel [5] have proposed and studied three cross-layer designs among physical, medium access control and routing (network) layers, using Received Signal Strength (RSS) as cross-layer interaction parameter for energy conservation, unidirectional link rejection and reliable route formation in mobile ad hoc networks.

Duc A. Tran and Harish Raghavendra [6] have proposed CRP, a congestion-adaptive routing protocol for MANETs. CRP tried to prevent congestion from occurring in the first place, rather than dealing with it reactively. A key in CRP design was the bypass concept. A bypass was a sub path connecting a node and the next non congested node. If a node was aware of a potential congestion ahead, it was found a bypass that was used in case the congestion actually occurred or. Part of the incoming traffic was sent on the bypass, was being made the traffic was being come to the potentially congested node less. The congestion was avoided as a result.

## 3. Genetic Algorithm based Congestion Aware Routing Protocol (GA-CARP) for MANET

The conventional hop count routing metric does not adapt well to mobile nodes. Several routing methods uses message exchanges like hello packets for the counter node mobility. These methods do not change the routes unless a link is broken, rather than taking precautions and make sure the link would not be broken. In this paper, a Genetic Algorithm based Congestion Aware Routing Protocol is proposed which employs the data rate, quality of the link MAC overhead. Congestion aware fitness function is used in the genetic algorithm to fetch congestion reduced routes.

### *3.1. Estimating quality of the link*

It is possible to forecast the link quality and discard the links with the lower signal strengths from the route selection using the received signal strength from the physical layer. When a sending node broadcasting RTS packet, it piggybacks its transmissions power, $P_t$ . On receiving the RTS packet, the intended node measures the signal strength received which holds the following relationship for free-space propagation model. For estimating quality of the link the below equation (2) is used.

$$\mathrm{P_r} = P_t(\lambda / 4\pi d^2).G_t.G_r \quad (1)$$

$$QoL = \mathrm{P_r} \quad (2)$$

Where $\lambda$ is the wavelength carrier, $d$ is distance between sender and receiver, $G_t$ and $G_r$ are unity gain of transmitting and receiving omni directional antennas, respectively. The effects of noise and fading are not considered.

### *3.2. Estimating MAC overhead*

In mobile ad hoc network, IEEE 802.11 MAC with the distributed coordination function (DCF) is considered. It has the packet sequence as request-to-send (RTS), clear-to-send (CTS), and data, acknowledge (ACK). The amount of time between the receipt of one packet and the transmission of the next is called a short inter frame space (SIFS). Then the channel occupation due to MAC contention will be

$$C_{occ} = t_{RTS} + t_{CTS} + 3t_{SIFS} \quad (3)$$

Where $t_{RTS}$ and $t_{CTS}$ are the time consumed on Request To Send (RTS) and Clear To Send (CTS), respectively and $t_{SIFS}$ is the Short Inter Frame Space (SIFS) period. The MAC overhead is hence calculated using the equation (4).

$$M_{oh} = C_{occ} + t_{acc} \quad (4)$$

where $t_{acc}$ is the time taken due to access contention.

### *3.3. Estimating data rate*

In mobile ad hoc networks, throughput through a given route is depending on the minimum data rate of its entire links. In a route of links with various data rates, when a high data rate node forwards more traffic to a low data rate node, there is a chance of congestion.

This leads to long queuing delays in such routes.

Since congestion considerably reduces the effectual bandwidth of a link, the link data-rate is computed by the equation (5)

$$D_{rate} = D_{size} / C_{delay} \quad (5)$$

where $D_{Size}$ is the data size and $C_{delay}$ is the channel delay.

*3.4. Representation, Initialization and Adaptive Repair Function*

The gene of the first locus encodes the source node followed by the gene of second locus is randomly taken from the nodes connected with the source node that is represented by the front gene's allele. A taken node is removed from the routing table in order to prevent the node from being selected twice which in turn avoiding loops in the path. This adaptive route repair mechanism continues until the destination node is reached. Random initialization is effected and hence the initial population is generated with the encoding method.

*3.5. Congestion Aware Fitness Function*

The fitness function interprets the chromosome in terms of physical representation and evaluates its fitness based on traits of being desired in the solution. The congestion aware fitness function (6) which involves computational efficiency and accuracy is defined as follows:

$$f_i = 1 / QoL.M_{oh}.D_{rate}[g_i(j), g_i(j+1)] \qquad (6)$$

where represents the fitness value of the i $^{th}$ chromosome, QoL is the quality of the link, $M_{oh}$ is the MAC overhead, $D_{rate}$ is the data rate. j is the next chromosome.

*3.6. Selection, Crossover and Mutation*

The selection operator used is stochastic universal sapling selection which is intended to improve the average quality of the congestion aware route by giving the high-quality routes which leads to a better chance to get copied into the next generation. Crossover operation examines the current routes in order to find better ones. The route undergoes mutation by an actual change or flipping of one of the genes of the candidate routes, which keeps away from local optima.

## 4. Result and Discussions

From the Fig.1 it is clearly seen that throughput is increased in GA-CARP when compared to AOMDV. The packet delivery ratio is increased in GA-CARP than AOMDV. Packet transmission delay between source and destination is reduced in GA-CARP and it is clearly visible in Fig.3.

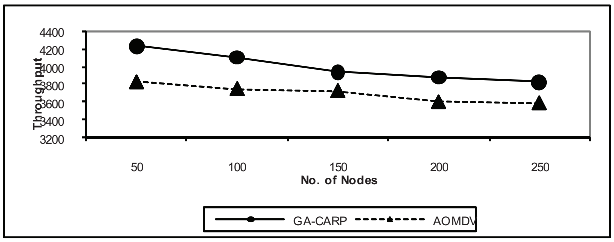


Fig.1. Number of Nodes Vs Throughput

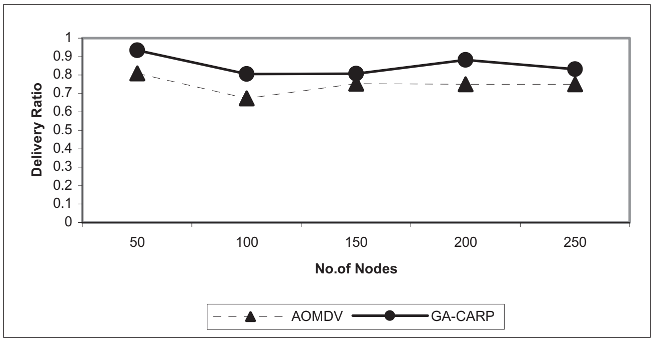


Fig.2. Number of Nodes Vs Delivery Ratio

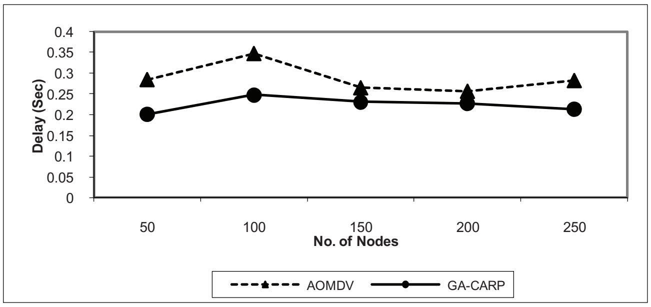


Fig.3. Number of Nodes Vs Delay

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