International Journal of Computational Intelligence and Informatics, Vol. 5: No. 1, June 2015

Performance Analysis of Genetic and Bees Colony Optimization Techniques for Finest Routing in Ad-Hoc Network

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Abstract- **An ad-hoc network is an infrastructure less network. Ad-hoc network is a seldom topology rottenly change their positions. The main destination of an ad-hoc network is to detect the shortest path between sources to destinations. Here using some evolutionary techniques to get an optimal path among topology. The proposed modified genetic algorithm is employed for the premature convergence of genes (PCG) with the help of a novel mutation operator and modified topology crossover (MTC), and also a simple bee's colony optimization algorithm also implemented and compared with MGA and AODV. Both the algorithms are applied with an Ad-hoc On-Demand Distance Vector (AODV) routing protocol. In a previous work genetic algorithm compared with the DSR routing protocol. Here QoS applied for evaluating the performance of routing protocols. The simulation results are managed with the help of network simulator 2 (ns2) tools. The proposed modified genetic algorithm shows the best results compared with other methods.**

Keywords- Ad-Hoc Network, AODV, DSR, Genetic Algorithm, Crossover, Mutation, PCG, BCO, Optimal Routing, QoS.

I. INTRODUCTION

Ad-hoc wireless networks are widely deployed due to their flexible structures. Mobile Ad-hoc network (MANET) is a set of mobile nodes that are dynamically and randomly located in such a manner that the wireless links among nodes are often changing due to MANET dynamic features. In such an environment, routing is one of the most important issues that have a significant impact on the network's performance.

An ideal routing algorithm should strive to find an optimum path for packet transmission within a specified time. There are several search algorithms for optimum path problem: the breadth-first search algorithm, the Dijkstra algorithm and the Bellman–Ford algorithm, to name a few. Since these algorithms can solve shortest path (SP) problems in polynomial time, they will be Effective in fixed infrastructure wireless or wired networks [1]. In Ad-hoc networks, routing protocols should be more dynamic to find a route very fast in order to have a good response time to the speed of topology change [2].

In Ad-hoc network, each node is placed in a seldom location and based on its coverage range, a neighbor list is discovered. The neighbors are used for the discovery of a route from a source to destination. For discovering the route,Ad-hoc network use two different types of protocols which are classified as Proactive and Reactive protocols [3]. Figure 1. shows a Simple Ad-hoc Network

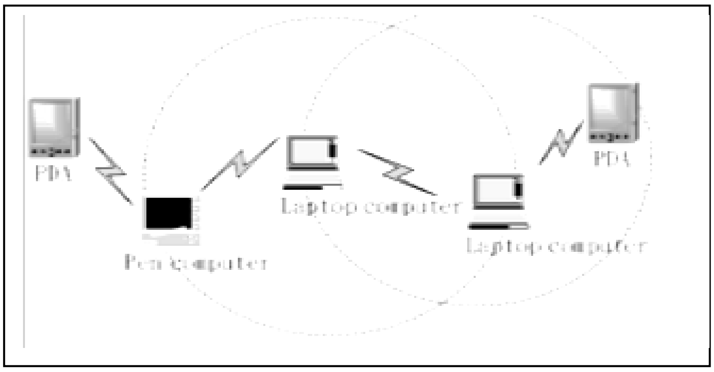

Figure 1. A Simple Ad-hoc Network.

This is simple and efficient protocol specifically designed for use in multi-hop wireless Ad-hoc networks. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which works together to allow nodes to discover and maintain routes to random destinations [4]. In this paper, a modified Genetic Algorithm and BCO based approach are proposed for solving the Shortest Path routing problem. Modified Topology Crossover Operator exchanges partial chromosomes and the novel mutation introduces two kinds of Boolean operators which produces new partial chromosomes. Figure 1. depicts the simple Ad-hoc network. Lack of positional dependency in respect of crossing sites helps to maintain diversity of the population. The proposed Modified Genetic Algorithm is compared with the AODV protocol for average end to end delivery delay vs. range, probability versus route failure ratio Packet delivery ratio and forwarding factor, desired route failure and throughput. This paper is organized into four sections. Section II discusses the genetic algorithm Section III discusses about genetic algorithm for adhoc network. Section IV discusses about the modified genetic algorithm. Section V discusses about Bee's colony optimization, Section VI concludes the work.

II. GENETIC ALGORITHM

Genetic Algorithm (GA) is inspired by the Darwin's Theory about evolution. GA was invented by John Holland in 1970[5]. GAs are an evolutionary optimization approach, they are particularly applicable to problems which are large, non-linear & possibly discrete in nature. Excellent references on GAs and their applications are found in [6]. GA try to work on principle of natural selection, as in natural selection over the time individuals with "good" genes survive whereas "bad" ones are rejected .GA collects the possible alternative solutions of a problem as genetic string [7].

A genetic algorithm maintains a population of candidate solutions (genetic string), where each candidate solution called a chromosome. The chromosome consists of sequences of positive integers that represent the IDs of nodes through which a routing path passes. Each locus of the chromosome represents an order of a node in a routing path. The gene of first locus is always reserved for the source node. The length of the chromosome is variable, but it should not exceed the maximum length, where is the total number of nodes in the network. A chromosome (routing path) encodes the problem by listing up node IDs from its source node to its destination node based on topological information database (routing table) of the network [1].

First, the current population is evaluated using the fitness evolution function and then ranked based on their fitness. A new generation is created with the goal of improving the fitness. Simple GA uses three operators with probabilistic rules: reproduction, crossover and mutation. First selective reproduction is applied to the current population so that the string makes a number of copies proportional to their own fitness. This results in an intermediate population. Second, GA selects "parents" from the current population with a bias that better chromosomes are likely to be selected. This is accomplished by the fitness value or ranking of a chromosome.

Third, GA reproduces "children" (new strings) from selected parents using crossover and/or mutation operators. Crossover basically consists of a random exchange of bits between two strings of the intermediate population. Finally, the mutation operator alters randomly some bits of the new strings [8].

A. Crossover

In traditional crossover operator two individuals are chosen from the population using the selection operator. A crossover site along the bit strings is randomly chosen the values of the two strings are exchanged up to this point. If S1=000000 and s2=111111 and the crossover point is 2 then S1'=110000 and s2'=001111 the two new offspring created from this mating are put into the next generation of the population. By recombining portions of good individuals, this process is likely to create even better individuals.

B. Mutation

In traditional mutation, use some low probability, a portion of the new individuals will have some of their bits flipped. Its purpose is to maintain diversity within the population and inhibit premature convergence. Mutation alone induces a random walk through the search space Mutation and selections (without crossover) create parallel, noise-tolerant, hill-climbing algorithms.

C. Genetic Algorithm Implementation

The objective (as stated above) is to minimize the Shortest Path routing problem [14]. To do so, number of hops is counted and the route having minimum hop count is selected and hence, these routes are utilized to minimize the delay efficiency.

D. Overview of AODV (Ad-hoc On-Demand Distance Vector)

The AODV Routing Protocol uses an on-demand approach for finding routes, that is, a route is established only when it is required by a source node for transmitting data packets. It employs destination sequence numbers to identify the most recent path. The major difference between AODV and Dynamic Source

Routing (DSR) stems out from the fact that DSR uses source routing in which a data packet carries the complete path to be traversed.

In AODV, the source node and the intermediate nodes store the next-hop information corresponding to each flow for data packet transmission. In an on-demand routing protocol, the source node floods the Route Request packet in the network when a route is not available for the desired destination. It may obtain multiple routes to different destinations from a single Route Request. The major difference between AODV and other on-demand routing protocols is that it uses a destination sequence number (DestSeqNum) to determine an up-to-date path to the destination. A node updates its path information only if the DestSeqNum of the current packetreceived is greater or equal than the last DestSeqNum stored at the node with smaller hop count. Figure. 2 shows the routing protocols of ad-hoc network.

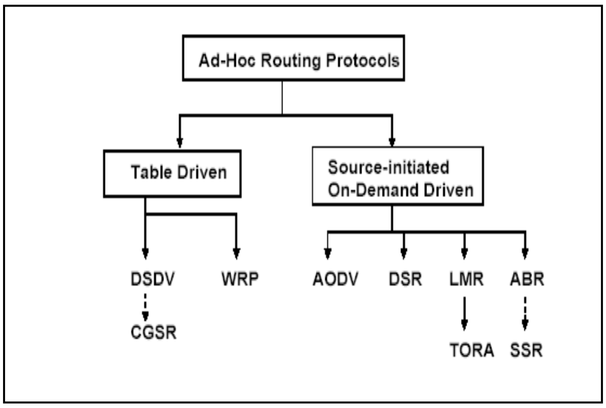

Figure 2. Ad-hoc Routing Protocols.

The steps for computation can generalized as [14]:

Step 1: The constraint limits is set for the Source Path route.

Step 2: Random values are generated between limits.

Step 3: The values of generated routes are put into the objective function

Step 4: The fitness evaluation is done for the various routes

```
fmax (n, 1) = max (fx (n, 1))
fmin(n,1) = min(fx(n,1)
For i=1: z
        ft (i,1) = (ftmax(n,1) - fmin(n,1)) - fx(n,1);
End
ftb = mean (ft);
For i = 1: z
        rl (i, 1) = ft (i, 1) / ftb;
End
```

Step 5: The best fit is calculated based on the equation (1).

Step 6: Selection based on the roulette wheel concept is done, the values providing the best fit being given a higher percentage on the wheel area so that values providing a better fit have higher probability of producing an offspring.

Step 7: Crossover is performed on strings using midpoint crossover. Crossover provides incorporation of extra characteristics in the off springs produced.

Step 8: Mutation is done if consecutive iteration values are the same.

Step 9: The new routes that satisfy the objective of minimization, and related parameters are plotted. Where: fx is the fitness value; ft = normalized fx; ftp=best fitness; fmax = fitness max; fmin = fitness min.

III. GENETIC ALGORITHM FOR AD-HOC NETWORK

Ad-hoc network under consideration is represented as a connected graph with N nodes. The metric of optimization is the cost of path between the nodes. The total cost is the sum of cost of individual hops. The goal is to find the path with minimum total cost between source node and destination node. This part presents a simple and effective Genetic Algorithm (GA) to find the shortest path. The details of the algorithm are given in the following subsections; while the investigation of the performance is achieved via a simulation work in the next section [9].

A. Representation of a chromosome

In the proposed algorithm, any path from the source node to the destination node is a feasible solution. The optimal solution is the shortest one. At the beginning a random population of strings is generated which represents admissible (feasible) or un-admissible (unfeasible) solutions. Un-admissible solutions are strings that cannot reach the destination. A chromosome corresponds to possible solution of the optimization problem. Thus each chromosome represents a path which consists of sequences of positive integers that represent the IDs of nodes through which a routing path passes with the source node followed by intermediate nodes (via nodes), and the last node indicating the destination, which is the goal. The default maximum chromosome length is equal to the number of nodes [14].

B. Evaluation of fitness function

The fitness function is defined as follows [14]:

$$fi = \frac{1}{\sum_{j-1}^{li-1} C_{gi}(j) + g_i(j+1)} \qquad (1)$$

Where, f_i represents the fitness value of the i^{th}chromosome, li is the length of the i^{th} chromosome, $g_i(j)$ represents the gene (node) of the j^{th} locus in the i^{th} chromosome, and C is the link cost between nodes[1]. In the proposed algorithm, the link costsare considered to be equal to each other and to 1. This means the cost which represents the shortest distance is the hop count [14].

C. Selection of Best fit

The selection process of the best fit is done to improve the average quality of the population. This process gives the better chance to the best chromosomes to survive. There are two basic types of selection process: proportionate and ordinal-based selection. Proportionate selection picks out chromosomes based on their fitness values relative to the fitness of the other chromosomes in the population. This selection includes roulette wheel selection, stochastic remainder selection and stochastic universal selection [10]. In this paper we are going to use the roulette wheel concept, the values providing the best fit being given a higher percentage on the wheel area so that values providing a better fit have higher probability of producing an offspring [14].

D. Modified Topology Crossover (MTC)

Crossover selects genes from parent chromosomes and creates a new offspring. Crossover is performed on strings using midpoint crossover. MTC is proposed by extending the operation of TC. In MTC, the traditional two point crossover is applied only on the topological part of the chromosome. The sequential part of the chromosome remains unchanged [12]. The offspring is generated from the two selected parents using the two selected points. New child C_i is formed from genes of the selected cut points from parent P_i and the genes exceptthe cut points from parent P_j and the vice versa for child C_j. Figure. 3 shows the Modified Topology Crossover.

Figure 3. Modified Topology Crossover.

E. Improved Mutation Operator

As we all know, invalid genes occupy, when GA converges prematurely. From the viewpoint of preventing premature convergence, it is important to maintain the diversity of genes in the same locus rather than the diversity of individuals in the population. Since we cannot identify which kind of genes is critical in a certain locus, we enable the alleles to exist in the same locus during the period of mutation. A new mutation operator proposed in [13] which is made up of two Boolean operators XOR / $\overline{XOR}$ expressed as

$$XOR = \begin{cases} a \otimes b = 0, if\,(a = b) \\ a \otimes b = 1, if\,(a \neq b) \end{cases} \tag{2}$$

$$\overline{XOR} = \begin{cases} a \circ b = 1, if\,(a = b) \\ a \circ b = 0, if\,(a \neq b) \end{cases} \tag{3}$$

This is a mutation operator different from the traditional one made up of one Boolean operator: NOT. Obviously mutation with the new genetic operator needs parents to provide two genes. According to the result of mutation is that the mutated genes in the same locus of two off- spring are in the state of compensation. As a result, the new mutation operator can to a high degree prevent premature convergence. Table I is an example that the genes in the 4th and 7th locus undergo mutation respectively [13].

TABLE I. THE GENES MUTATION

Operators	Genes Mutation	
	Parents	***Offspring***
XOR $\overline{XOR}$	011**1**01**0** ↓ ↓ 110**1**01**1**	011**0**01**1** ↓ ↓ 110**1**01**0**

Before mutation, there are two different genes in the 4th locus and genes in the 7th locus are the same while they are mutually exclusive in their own locus after mutation.

IV. MODIFIED GENETIC ALGORITHM

The Proposed objective (as stated above) is also to minimize the Shortest Path routing problem. To do so, number of hops is counted and the route having minimum hop count is selected and hence, these routes are utilized to minimize the delay efficiency [11].

The steps for computation can generalized as:

Step 1: The constraint limits is set for the Source Path route.

Step 2: Random values are generated between limits.

Step 3: The values of generated routes are put into the objective function

Step 4: The fitness evaluation is done for the various routes

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fmax (n, 1) = max (fx (n, 1))
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For i = 1: z
        rl (i, 1) = ft (i, 1) / ftb;
End
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Step 5: The best fit is calculated based on the equation (1)

Step 6: Selection based on the roulette wheel concept is done, the values providing the best fit being given a higher percentage on the wheel area so that values providing a better fit have higher probability of producing an offspring.

Step 7: Modified topology Crossover is (MTC) performed on strings using midpoint crossover. Crossover provides incorporation of extra characteristics in the off springs produced.MTC is proposed by extending the TC.

Step 8: Modified Mutation is done if consecutive iteration values are the same traditional mutation used NOT only but proposed modified GA used XOR / $\overline{\text{XOR}}$ operators.

Step 9: The new routes that satisfy the objective of minimization, and related parameters are plotted. Where: fx is the fitness value; ft = normalized fx; ftp=best fitness; fmax = fitness max; fmin = fitness min.

V. BEES'S COLONY OPTIMIZATION

Like the ant colony optimization Artificial Bee Colony Optimization (BCO) model is a new and basic general purpose Swarm Intelligence (SI) optimization technique which is based on efficient labor employment and efficient energy consumption and called as multi-agent distributed model. In the Ant Colony Optimization (ACO) model we adopted mainly one natural insect behavior which is the food searching.

The main aims to discover the shortest path between the home and the food source place but from BCO model we adopted mainly two natural behaviors which is the social bee's life like the mating process behavior and the foraging process behavior [6].

Main steps of the algorithm are given below [17]:

Step 1: Initialize the food source positions.

Step 2: Each employed bee produces a new food source in their food source site and exploits the better source.

Step 3: Each onlooker bee selects a source depending on the quality of her solution, produces a new food source in selected food source site and exploits the better source.

Step 4: Determine the source to be abandoned and allocate its employed bee as scout for searching new food sources.fmax (n, 1) = max (fx (n, 1))

Step 5: Memorize the best food source found so far.

Step 6: Repeat steps 2-5 until the stopping criterion is met.

We can calculate the value of the fitness function using following equation [17].

Fitness function: $$fit_i = \begin{cases} \frac{1}{1+f_i} if \quad f_i \geq 0 \\ 1+abs(f_i) if \quad f_i \prec 0 \end{cases} \quad (5)$$

The following formula produces a new solution [17].

$$V_{i,j}=X_{i,j}+\Phi_{ij}(X_{i,j}-X_{k,j}) \quad (6)$$

Where,

k=1; k is a random selected index.

j=0; *j* is a random selected index.

To Calculate the probability values *p* for the solutions *x* by means of their fitness for onlooker bees using the following equation [17].

$$P_i = \frac{fit_i}{\sum_{i=1}^{cs/2} fit_i} \quad (7)$$

Where cs =colony size.

In the ad hoc network the protocols for routing is defined as in the transport layer. So according to the diagram the node hive is lye in between network layer and application layer. So entrance floor is work as the interface for the media access control protocol of the network layer and deals with incoming and outgoing packets. If the hive node is the internal node then at the entrance scout received the packet if it has live time and broadcast it further.

VI. SIMULATION RESULTS

The simulations were performed using Network Simulator 2 (NS-2), particularly popular in the Ad-hoc networking community. The traffic sources are CBR (continuous bit –rate). The source-destination pairs are spread randomly over the network. The mobility model uses random waypoint model in a rectangular filed of 500m x 500m with 20 nodes. Table II is a simulation environment properties.

TABLE II. SIMULATION ENVIRONMENT

S.No.	Simulation Parameters	
	Parameter	***Value***
1	Simulation	NS-2
2	Protocol Studied	DSR, AODV
3	Simulation time	200 Sec
4	Simulation area	500 * 500
5	Transmission range	250 m
6	Node Movement Model	Random Way point
7	Bandwidth	2 mbps
8	Traffic type	CBR
9	Data Payload	Bytes/packet

A. *Packet delivery Ratio (PDR)*

The packet delivery fraction is defined as the ratio of number of data packets received at the destinations over the number of data packets sent by the sources. This performance metric is used to determine the efficiency and accuracy of Ad-hoc routing protocols [16]. Figure. 4 shows the packet delivery ratio of each protocol compared with Modified GA.

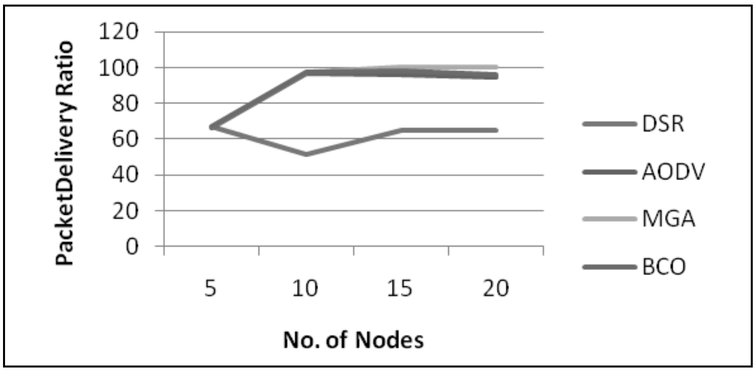
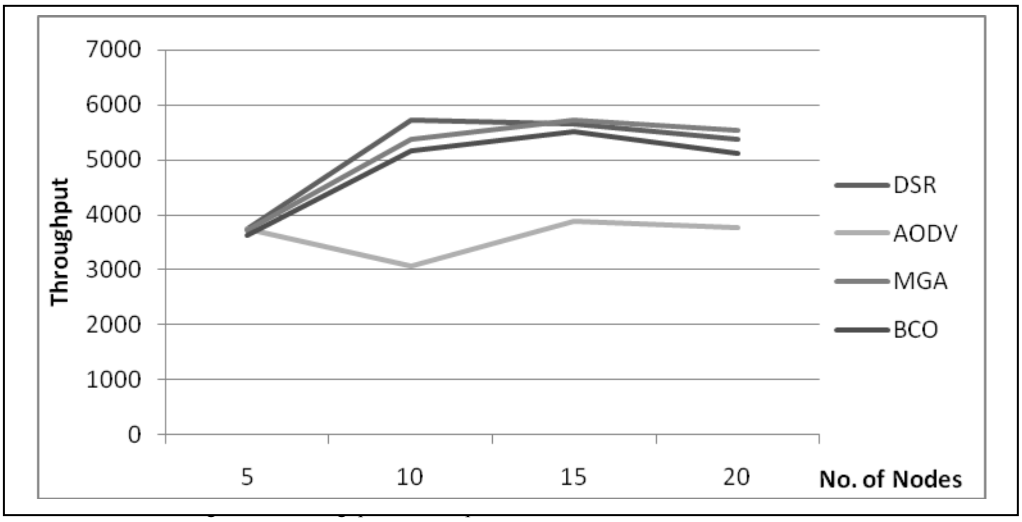


Figure 4. Packet Delivery Ratio for each protocol V_s MGA

B. *Throughput*

A network throughput is the average rate at which message is successfully delivered between a destination node (receiver) and source node (sender). It is also referred to as the ratio of the amount of data received from its sender to the time the last packet reaches its destination. Throughput can be measured as bits per second (bps), packets per second or packet per time slot. For a network, it is required that the throughput is at high-level [15].

Figure. 5 shows the throughput of each protocol compared with Modified GA. It is the average of the total throughput. It is also measured in packets per unit TIL. TIL is Time Interval Length. AODV performs well than DSDV since AODV is an on-demand protocol.



C. *Average End-to-End Delay*

This is the average time involved in delivery of data packets from the source node to the destination node. To compute the average end-to-end delay, add every delay for each successful data packet delivery and divide that sum by the number of successfully received data packets [16]. Figure. 6 shows the average end-to-to delay

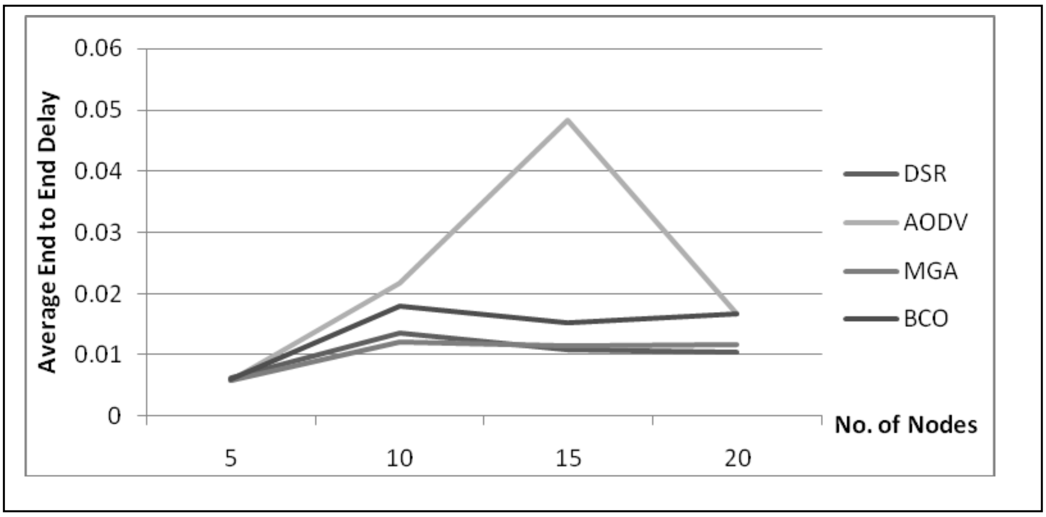


Figure 6. Average End-to-End Delay for each protocol V_s MGA

VII. CONCLUSION

Here Performance Analysis of routing protocols DSR, AODV in Ad-hoc network using evolutionary techniques are implemented. An Evolutionary technique used to select optimal path between source host and destination host. A novel approach of genetic algorithm used Modified topology crossover and mutation operations. In traditional mutation performed NOT operation only but the modified mutation used XOR and $\overline{XOR}$ operations for Premature Convergence of genes. The simulation model consists of region where nodes are randomly moving to each ther. For each protocol, we calculated three performance criteria.

- Packet Delivery Ratio
- Average Throughput
- Average End to End Delay

By simulating we can argue that if delay is our main criteria then DSR can be our best choice only in small network. But if throughput and packet loss ratio are our main parameters for selection, then AODV gives better results compare to others because its throughput and packet delivery ratio is best among others. If we consider the parameter, Maximum number of packets, we notice that that the throughput for the three routing protocols is almost constant for a maximum queue length greater than 30. As the maximum queue length decreases, the throughput decreases. A comparative analysis of MGA and BCO with AODV and DSR shows better performance of MGA over other methods.

In the future, complex simulations could be carried out to gain a more in depth performance analysis of the ad-hoc wireless networks by considering other metrics like power consumption, the number of hops to route the packet, fault tolerance, minimizing the number of control packets etc. and use some other Evolutionary algorithms to solve some of ad-hoc routing protocol problems.

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