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DIVERSIFIED OPTIMIZATION TECHNIQUES FOR ROUTING PROTOCOLS IN MOBILE AD-HOC WIRELESS NETWORKS

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ABSTRACT

Mobile Ad-hoc Network (MANET) is a wireless network without having a fixed infrastructure. The lack of infrastructure introduces various constraints on Ad-hoc networks. The selection of routing protocol is a big challenge in Ad-hoc network because of its dynamic behavior. This work mainly focusses to analyze the performance of hybrid (Zone Routing Protocol) routing protocol, which combines the best features of proactive (Optimized Link State Routing) and Reactive (Ad-hoc On-demand Distance Vector) routing protocols using different performance metrics like Throughput, End-to- End Delay, Packet Delivery Ratio, Power Consumption and Packet loss ratio. In this work, Genetic Algorithm and Ant Colony Optimization technique are proposed to improve the performance of MANETs.

Keywords: mobile Ad-hoc networks (MANET), proactive routing, reactive routing, hybrid routing, optimized link state routing (OLSR), Ad-hoc on-demand distance vector (AODV), zone routing protocol (ZRP), genetic algorithm (GA), ant colony optimization (ACO).

1. INTRODUCTION

Wireless network routing connects two different networks together using a router. Need for local network chose with a need to share data between two or more computers, creating local links. To connect with their local networks together to route data between the networks without have all data shared with everyone and everywhere, routers were designed.

1.1 MANET

Mobile Ad-hoc networks are communication networks where nodes are movable. Communication between various nodes is achieved through wireless links in a multihop fashion. All nodes serve as routers for each other. The intention of routing is directing data flows from source to destination. This is a challenge in MANET due to mobility of nodes and ineffective paths [1]. MANET has some attributes like simplicity of use, continually changing topology, wireless connection and distributed operations [2]. Ad-hoc networks have been becoming popular due to multiple applications provided by these networks. The reasons for the change in topology may be are low transmission power. Because of interference and fading due to high operating frequency in an urban environment, the links are unreliable [3]. Ad-hoc networks are becoming popular due to multiple applications provided by these networks. Because of interference and fading due to high operating frequency in an urban environment, the links are unreliable [4]. The MANETs is a collection of wireless mobile nodes having no well established infrastructure and dynamically changing topology in nature. Due to frequent changes in topology and infrastructure less nature, Ad-hoc networks require highly adaptive routing algebraic approaches [5].

1.2 Genetic Algorithm

Genetic Algorithms (GA) are based on the principles of natural selection discovered by Charles Darwin. It provides a great solution for the expensive computation time. In the modern world, genetic material is replaced by bits and natural selection is replaced by a fitness function in computers.

Genetic Algorithm solves a variety of optimization problems, including problems in which the intention function is irregular, no differentiable, stochastic, or highly nonlinear. The genetic algorithm can tackle problems of mixed integer programming, where some components are limited to be integer-valued.

1.3Ant Colony Algorithm

Ant Colony Optimization (ACO) is a subset of swarm intelligence and considers the capability of simple ants to resolve complex problems by cooperation. The exciting point is, that the ants do not need any direct communication for the solution process, instead they communicate by a mechanism of indirect communication. Several algorithms which are based on ant colony problems were introduced for solving different optimization problems.

This study proposes an optimization technique like Genetic Algorithm and Ant Colony Algorithm to optimize the Ad-hoc routing protocols. The optimization technique is implemented in the proactive routing protocol, OLSR, reactive routing protocol AODV and hybrid routing protocol ZRP. The performance indices such as Throughput, End-to- End Delay, Packet Delivery Ratio, Power Consumption and Packet Loss Ratio are presented and analyzed.

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2. MOBILE AD-HOC ROUTING NETWORK

The Routing Protocols for Ad-hoc wireless networks can be divided into three categories based on the routing information update mechanism. They could be Proactive (Table-driven), Reactive (On-demand) or Hybrid (both proactive and reactive). Figure-1 shows further classification of the routing protocols in MANETs.

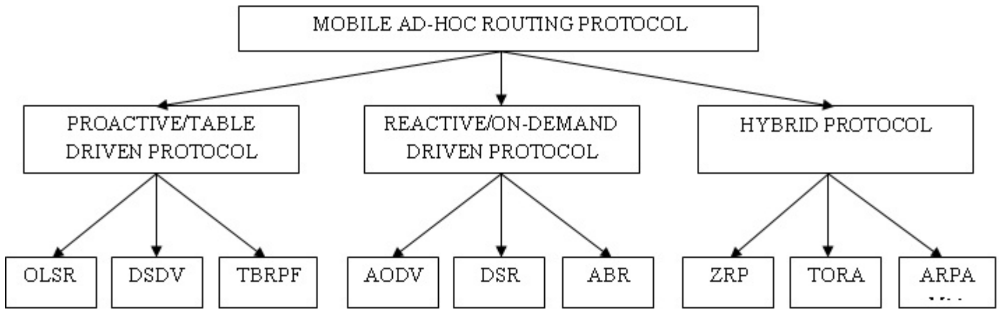

Figure-1. MANET routing protocols.

2.1 Proactive routing protocol

Proactive Routing Protocols sustain routes to all nodes, including nodes to which no packets are sent. Such methods take action to topology changes, even if no traffic is exaggerated by the changes. They are also called table-driven methods. The main advantage of this category of protocols is that hosts can quickly acquire route information and quickly set up a session. The disadvantage of proactive routing protocols may waste bandwidth since control messages are sent out unnecessarily when there is no data traffic. In this work, Optimized Link State Routing (OLSR) is chosen for analysis of proactive routing protocol.

2.2 Reactive routing protocol

Reactive Routing Protocols are based on the requirement for data transmission. Routes between hosts are determined only when they are explicitly needed to forward packets. Reactive methods are also called on-demand methods. Since there is no need to update the route information periodically and do not need to find and maintain routes on which there is no traffic they can drastically reduce routing overhead when the traffic is lightweight and the topology changes less severely. The major disadvantages are delayed will be more, while establishing the routes for forwarding the data and excessive flooding of the control messages that may lead to network obstruction. In this work, Ad-hoc On-demand Distance Vector (AODV) is chosen for analysis from reactive protocol.

2.3 Hybrid routing protocol

Hybrid routing protocols are the combination of proactive and reactive routing protocols. It minimizes the extensive bandwidth use alike proactive routing protocols, and reduces the delay alike reactive routing protocols. In this work, Zone Routing Protocol (ZRP) is chosen for analysis from hybrid protocol.

3. RELATED WORK

A hybrid optimization technique using Ant Colony Optimization and Cuckoo Search is to achieve the improved performance in terms of average end-to-end delay is discussed in [1].

The performance of reactive (AODV), proactive (OLSR) and Hybrid (ZRP) routing protocols with and without black hole attack using different performance metrics like Packet Delivery Ratio, Average Jitter, Average Throughput and Average End-to-End delay is analyzed in [2].

In [3], the performance of the existing ZRP for ad-hoc network is improved. Qualnet 5.0.2 network simulator had been used for obtaining simulation results as it reduces considerably the average End-to-End delay and control overhead.

The performance evaluation metrics employed for wireless and Ad-hoc routing algorithms is routing overhead, route optimality and energy consumption. This survey provides a collection of swarm intelligence based algorithms for mobile Ad-hoc and sensor networks and their critical analysis [4].

In [5], some characteristics as well as the performance analysis of the proposed ACO based Ad-hoc routing protocols are analyzed and compared them with the well known Ad-hoc routing protocols.

Dilpreet kaur, Naresh kumar presented to describe the characteristics of Ad-hoc routing protocols AODV, OLSR, TORA, DSR and DSDV based on the performance metrics like packet delivery fraction, average delay, normalized routing load, throughput and jitter under low mobility and low traffic network as well as under high mobility and high traffic network [6].

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4. PROPOSED METHOD

In this work, the performance of MANETs using a Genetic algorithm and Ant Colony optimized, OLSR protocol for proactive routing, AODV protocol in reactive routing and ZRP protocol for hybrid routing are taken for analysis. The Genetic Algorithm and Ant Colony optimization technique are chosen to find the best next hop neighbor.

4.1 AODV: Ad-hoc On-demand Distance Vector

Ad-hoc On-demand Distance Vector (AODV) is an on-demand protocol designed for mobile Ad-hoc networks. AODV discover a source to destination route only on-demand. For maintaining route information it uses a route finding procedure and routing tables. This protocol responds quickly to changing link conditions and link breakages. The nodes mark the routes as invalid whenever there is a link breakage. Loop freedom in AODV is ensured by using destination sequence numbers. These also allow nodes to use the most recent route to a destination. The routing table information includes the destination address and the next hop address with the number of hops required to reach the destination. Also, the most recent destination sequence number associated with the destination and the lifetime of the route is stored in the table. If during the lifetime, the route is not used, the routing table entry is discarded.

The basic operation of AODV can be divided into three phases:

Route discovery

Route maintenance

Acknowledge messages

The message types defined by AODV are Route Request (RREQ), Route Reply (RREP) and Route Error (RERR)

4.2 OLSR: Optimized Link State Routing

OLSR protocol always maintains the shortest path to reach all possible destinations in the network. So, it is more cautious to estimate the quality of links before adding them in the topological information that serves to calculate the best routes. The quality of a link can be predicted based on the power of the received signal. This information is provided by some wireless network cards. If this information is not available, OLSR protocol predicts the link quality based on the number of missing control messages. Failure of link can be detected using the timer expiry or by the link layer that informs upper layers of the failure with a neighbor node after attaining the maximal number of retries

The core functioning of OLSR can be divided into three processes namely:

a) Neighbor/Link Sensing

b) Estimate the quality of links

c) Optimal path calculation using a shortest path algorithm

4.3 ZRP: Zone Routing Protocol

By using Zone Routing Protocol, the benefits of both proactive and reactive routing protocols can be attained. In this protocol, each node proactively maintains routes within a local region, which is termed as the rooting zone. The query - reply mechanism is done to create routes. While creating different zones in the network, a node first identifies its neighbor's neighbor is defined as a node which has a direct communication with other node within a transmission range. ZRP uses a query control mechanism to minimize route query traffic by directing query messages outward from the query source and away from cover routing zones. A route query has been received by a covered node which belongs to the routing zone of a node. A node checks the incoming query packet whether it is coming from its neighbor or not before forwarding. If yes, it makes all of its known neighboring nodes in its same zone as covered. The query is thus relayed until reaching the destination. The destination in turn sends back a reply message via the reverse path and creates the route.

4.4 Genetic algorithm

The basic principle of Genetic algorithm is the chromosomes with an enhanced fitness value which have a higher probability of being inherited into the next generation. To attain this, all the chromosomes are placed downwards according to their fitness, so the chromosomes with high fitness are positioned on the top of arranging list. Then the list is separated into two different disjoint sets with some chromosomes in upper class and some chromosomes in the lower class.

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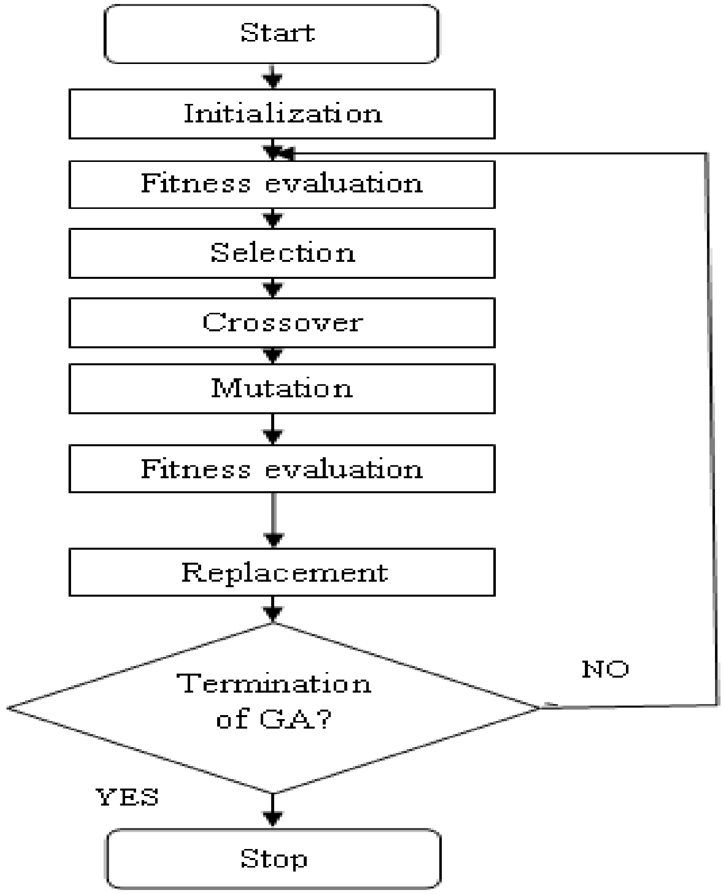

Figure-2. Flowchart for Genetic Algorithm (GA) optimization.

During crossover one chromosome from the upper class and another from lower class is selected to create a new one. Genetic Algorithm analyzes the characteristics of every node and provides information about the attacks. Genetic Algorithm uses the features of OLSR, AODV and ZRP such as Request Forwarding Rate; Reply, Receive Rate.Figure-2 displays the flow chart of Genetic Algorithm optimization technique.

4.5 Ant colony optimization

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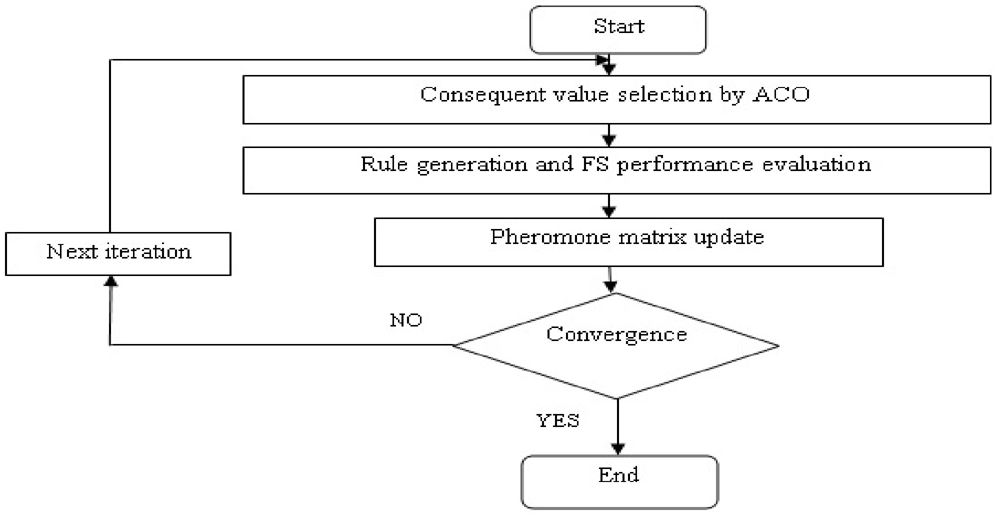

Figure-3. Flowchart of Ant Colony Optimization (ACO).

The basic principle of the Ant Colony Optimization technique finds the shortest path between their nest and a food source. Ants are capable to find the shortest path between their nest and food source, without any visible, central and active coordination mechanism. The path optimization is achieved by exploiting the pheromone quantity dropped by the ant. An artificial ant acts as a simple computational agent. In the accomplishment of artificial ant, probabilistically path selection mechanism is introduced. The ACO based metaheuristic approaches are especially suitable for the problem scenarios where optimized multi-path section is desired. The ACO based algorithms are based only on local information, so there is no need for transmission of routing tables or other information to neighbor nodes in networks. The selection decision is made based on the pheromone value of the current node. It provides the multi-path selection choices. Various applications based on meta-heuristic algorithmic approaches, are stochastic optimization problems, NP-hard, industrial problems, dynamic optimization problems, telecommunication networks, multi-objective optimization and continuous optimization. Figure-3 shows the flowchart of Ant Colony Optimization technique.

5. SIMULATION

The proposed work is implemented using the NS2 simulator tool. Performance analysis is carried out by setting 100 nodes with a grid size of 1000×1000 m. The performance evaluation is based on the different parameters such as packet size, data packets send, data packets received and number of packets delivered. Packet delivery ratio, throughput, end-to-end delay, packet loss ratio and power consumption are measured to know the performance of the proposed method. The chosen parameters are given in Table-1.

Table-1. Simulation parameters.

Parameter	Value
Surface of the network	$1000m^2$
Number of nodes	100
Size of data packet	500 Byte
E_{el}	50nJ/bit
RTS, CTS, ACK size	30 Bytes
Traffic type	Constant Bit Rate (CBR)
Routing protocol	AODV, OLSR, ZRP
Antenna type	Omni-Antenna
Channel bandwidth	20kpbs
Initial energy	2J
Transmission range	250m

5.1 Performance metrics

5.1.1 Packet Delivery Ratio (PDR)

PDR is the ratio between packets received by the destination and the packet generated at the source. Packet delivery ratio=D/S.

Where, D=number of packets received by the destination.
S=number of packets generated at the source.

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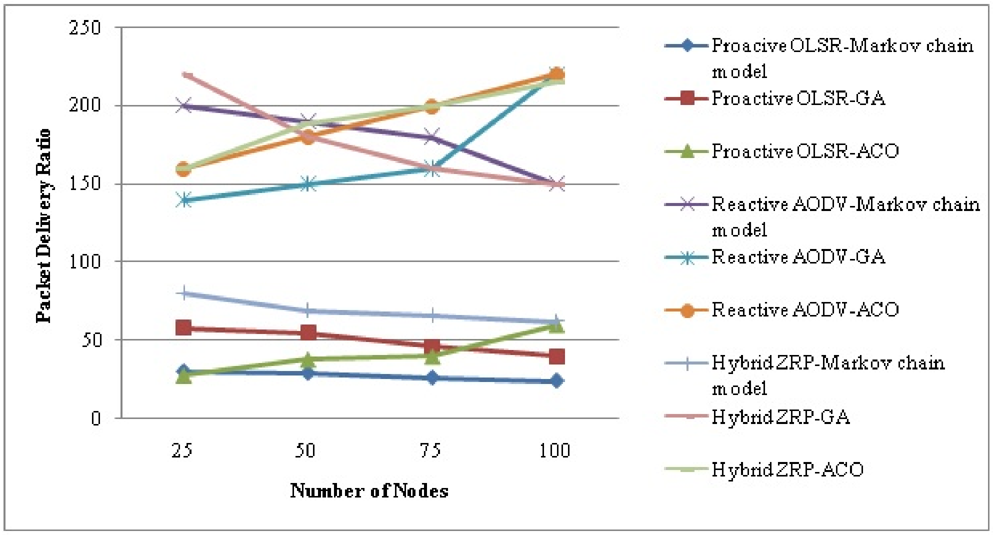

Figure-4. Packet delivery ratio vs. No. of nodes.

Table-2. Packet delivery ratio with 100 nodes.

	Various protocols	**Packet delivery ratio**		
		Markov chain	**Genetic Algorithm** (GA)	**Ant Colony Optimization** (ACO)
Number of nodes is 100	Proactive OLSR	24	40	60
	Reactive AODV	150	220	220
	Hybrid ZRP	62	150	215

Figure-4 shows the Packet Delivery Ratio Vs. No. of nodes and Table-2 compares the Packet Delivery Ratio for 100 nodes for various protocols.

The packet delivery ratio is higher in ant colony optimized reactive AODV and hybrid ZRP, whereas ant colony optimized proactive OLSR has the least PDR. For better performance the value of the packet delivery ratio must be greater. Therefore ant colony optimized reactive AODV and hybrid ZRP packet delivery ratio is best among all the three routing protocol.

5.1.2 Average End-to-End delay

The average time for a data packet to reach the destination. The calculation is done by subtracting time at which first packet was transmitted from source from the time at which first data packet arrived to destination. For better performance the value of End-to-End delay must be low.Average End-to-End delay=S/N.

Where S =sum of the time spent to deliver packets for each destination.

N= number of packets received by the all destination nodes.

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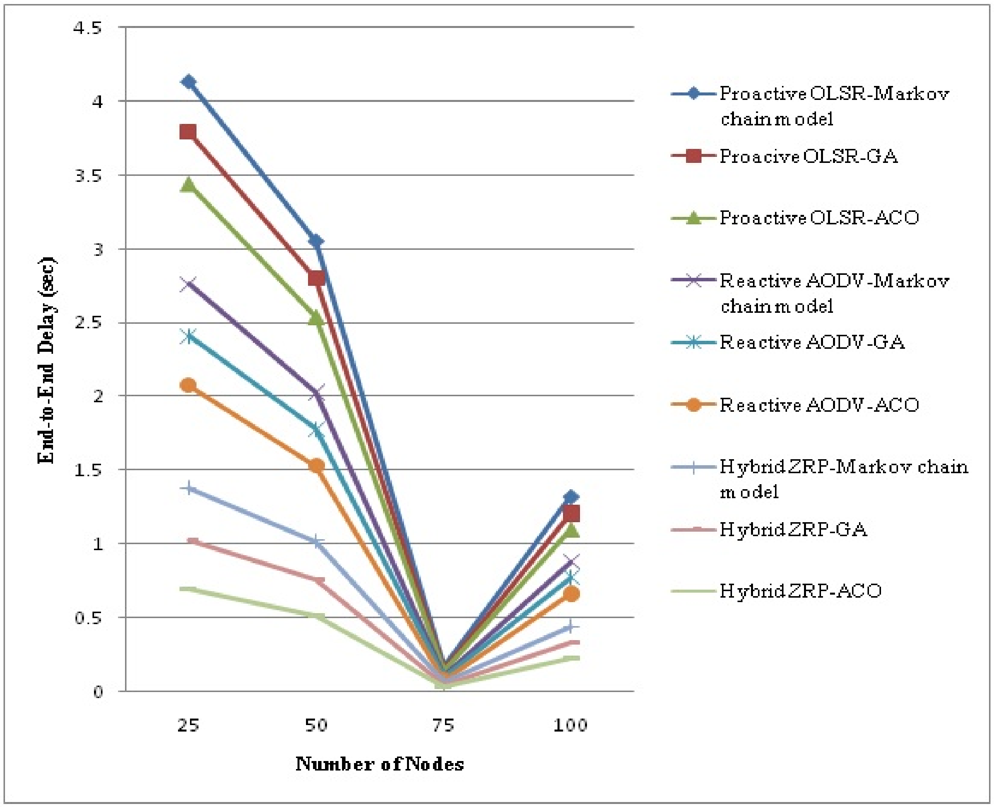

Figure-5. End-to-End delay vs. No. of nodes.

Table-3. End-to-End delay with 100 nodes.

	Various Protocol	**Average End-to-End delay**		
		Markov chain	**Genetic Algorithm** (GA)	**Ant Colony Optimization** (ACO)
No.of node 100	Proactive OLSR	1.32	1.21	1.1
	Reactive AODV	0.88	0.77	0.66
	Hybrid ZRP	0.44	0.33	0.22

Figure-5 shows the End-to-End delay Vs. No. of nodes and Table-3 compares the End-to-End delay for 100 nodes for various protocols.

End-to End delay is lower in ant colony optimized hybrid ZRP, whereas ant colony optimized proactive OLSR has the higher End-to End delay. The lesser the propagation time, transmission time, queuing time and processing time the better End-to- End delay. The lesser time period is acquired by ant colony optimized hybrid ZRP.

5.1.3 Throughput

The total amount of data received by the receiver from the sender divided by the time taken from the receiver to get the last packet. The throughput is measured in bits per second (bit/s or bps).

Using Little's Law, Throughput=R/T.

Where the R - amount of data received by the receiver

T-Time taken for delivery

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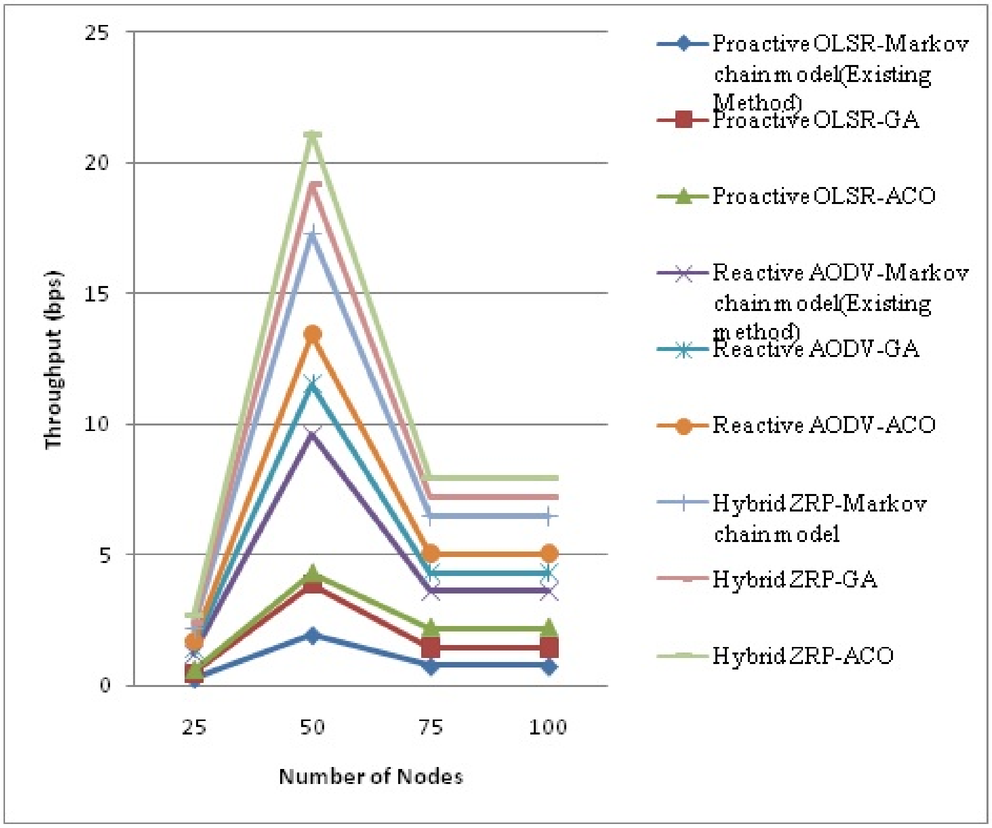

Figure-6. Throughput vs. No. of nodes.

Table-4. Throughput for 100 nodes.

	Various protocols	**Throughput**		
		Markov chain	**Genetic Algorithm** (GA)	**Ant Colony Optimization** (ACO)
No.of node 100	Proactive OLSR	0.72	1.44	2.22
	Reactive AODV	3.6	4.32	5.04
	Hybrid ZRP	6.48	7.2	7.92

Figure-6 shows the Throughput Vs. No. of nodes and Table-4 compares the Throughput for 100 nodes for various protocols. Ad-hoc wireless networks should attempt to maximize the throughput of the system. In our proposed methods, throughput is higher in ant colony optimized hybrid ZRP, whereas ant colony optimized proactive OLSR has the least throughput. Ant colony optimized hybrid ZRP throughput is best among all the three routing protocol.

5.1.4 Packet Loss Ratio (PLR)

PLR is the ratio of the number of packets lost from source to destination.

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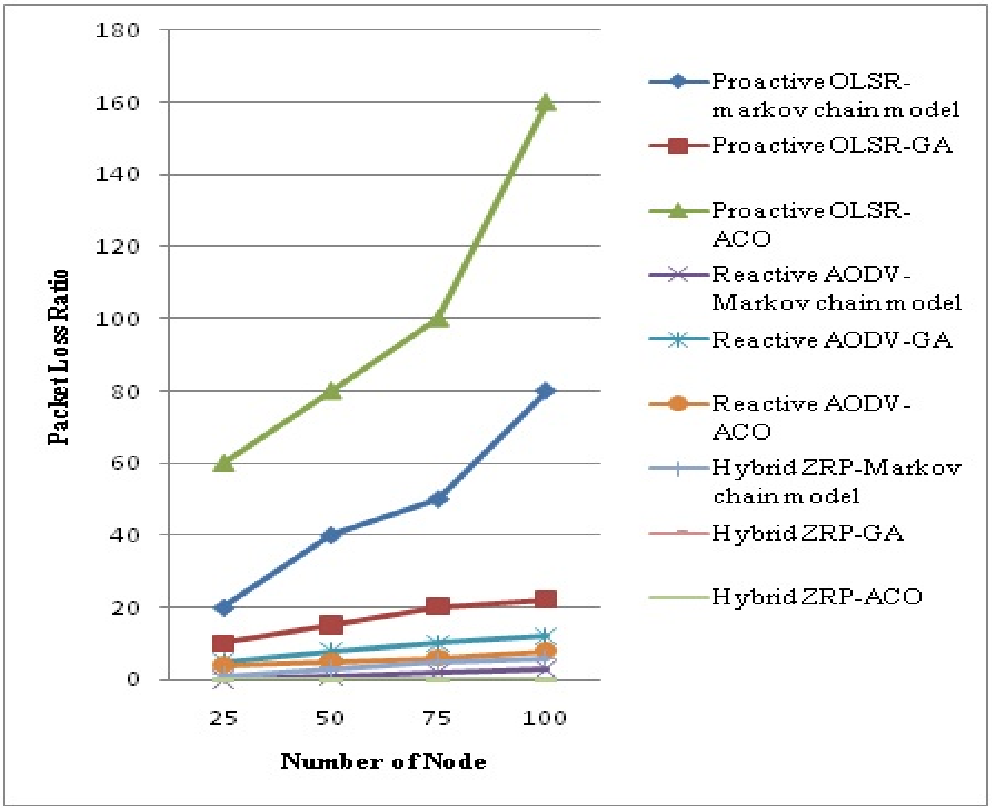

Figure-7. Packet loss ratio vs. No. of nodes.

Table-5. Packet Loss Ratio with 100 nodes.

No.of node 100	**Various Protocol**	**Packet loss ratio**		
		Markov chain	**Genetic Algorithm** (GA)	**Ant Colony Optimization** (ACO)
	Proactive OLSR	80	22	160
	Reactive AODV	3	12	8
	Hybrid ZRP	6	0.05	0.04

Figure-7 displays the Packet Loss Ratio Vs. No. of nodes and Table-5 compares the Packet Loss Ratio for 100 nodes for various protocols.

The packet loss ratio should attempt to minimize the loss of the system. Packet loss ratio is lesser in ant colony optimized hybrid ZRP, whereas ant colony optimized proactive OLSR has the very high packet loss ratio. Therefore ant colony optimized hybrid ZRP packet loss ratio is best among all the three routing protocol.

5.1.5 Power Consumption

It is the total amount of energy consumed by a process or system.

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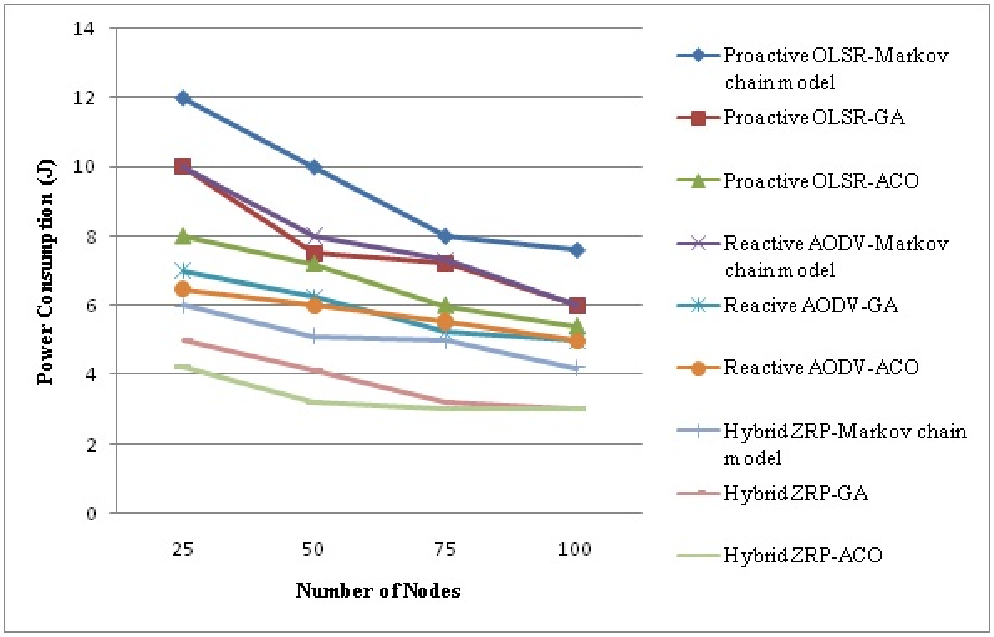

Figure-8. Power consumption vs. No. of nodes.

Table-6. Power consumption with 100 nodes.

No.of node 100	Various Protocol	Power consumption		
		Markov chain	**Genetic Algorithm** (GA)	**Ant Colony Optimization** (ACO)
	Proactive OLSR	7.6	6	5.4
	Reactive AODV	6	5	5
	Hybrid ZRP	4.2	3	3

Figure-8 shows the Power Consumption Vs No. of nodes and Table-6 compares the Power Consumption for 100 nodes for various protocols.

Power consumption is less in ant colony optimized hybrid ZRP, whereas Ant colony optimized proactive OLSR has higher power consumption. So ant colony optimized hybrid ZRP power consumption is best among all the three routing protocol.

6. CONCLUSIONS

In this paper, the performance of the mobile Ad-hoc networks has been enhanced by using the Genetic Algorithm and Ant Colony Optimization algorithm. Among the various available protocols, proactive (OLSR), reactive (AODV) and hybrid (ZRP) have been considered in this analysis. The effectiveness of the proposed Ant Colony Optimization algorithm has been realized by comparing the results with the results obtained from Genetic Algorithm and Markov chain model. The performance metrics like Throughput, End-to-End Delay, Power Consumption, Packet Delivery Ratio and Packet Loss Ratio were computed using the NS-2 simulator. From the simulated results it has been observed that the ant colony optimized ZRP protocol provides better results.

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