A Review on Quality-of-Service Multicast Routing Techniques Based on Genetic Algorithm in Manet

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Abstract--- Mobile Ad Hoc Network is a collection of mobile nodes that communicates with each other over wireless links. MANETs are dynamic and self configuring networks with self-administration. Due to mobility of nodes in MANETs which results in frequent and arbitrarily changes in network topology, providing quality of service of multicast routing in MANETs is a challenging and critical task. Different approaches such as Genetic algorithms, Swarm intelligence, ACO techniques, fuzzy Logic and Neural Networks to support QoS in MANETs are proposed by the researchers. Genetic Algorithms are proved as a good approach for routing in MANETs. The main reason behind that is Genetic Algorithms are searching algorithms belongs to the class of evolutionary algorithms (EAs), which generate solutions to optimization problems using techniques inspired by natural evolution. QoS routing and to find optimal and feasible paths is a NP-Complete problem. Genetic Algorithm gives promising results to such critical problems. In this paper QoS based multicast routing techniques based on Genetic Algorithm (GA) are reviewed that determine routes based on QoS constraints based on GA.

Keywords: MANET, Quality of service (QoS), Genetic Algorithm (GA), Multicasting, Multi-objective Genetic Algorithm, Routing.

I. INTRODUCTION

Mobile Ad Hoc Networks (MANETs) are autonomous networks without any pre-existing infrastructure. MANET is a wireless network of devices with dynamic topology network [7, 9]. If the location of two movable nodes is within the range of each other, they can communicate directly. When one mobile node moves in transmission range of another mobile node a wireless link is created and the link is destroyed when the mobile node moves out of range of a mobile node. Thus the topology of MANETs is dynamic and can change unpredictably. Quality of service can be defined as a set of services requirements that needs to be satisfied by a network at the time while transporting information form

source to destination. The main goal of QoS routing is to find optimal and efficient routes based on QoS constraints such delay, delay variation, cost and packet loss. QoS routing works under number of constraints so it is more typical and complicated than regular routing. Because of changing network topology frequently in MANETs, it is challenging to provide QoS guarantee. QoS multicast routing is one of the challenging issues which aims to find optimal and feasible paths from one source to multiple destinations while satisfying QoS metrics. There are many different methods that can be used to solve QoS based multicast routing problems such genetic algorithms fuzzy logic, neural networks, ant colony optimization algorithms which are heuristic methods to find feasible paths. In this paper genetic algorithm based QoS multicast routing techniques are described which have their own set of QoS metrics.

II. ROUTING IN MANETS

A routing function is needed for communication among nodes by forwarding data packets among them. In MANETs routing protocols can be categorized into three categories:

Proactive Protocols

Proactive routing protocols are table driven routing protocols that stores routing information in routing tables. Proactive routing protocols maintain consistent and up to date routing information about each and every node in network. The information is updated periodically or when topology changes throughout the network. Destination-Sequenced Distance Vector (DSDV) and Fisheye State Routing (FSR) protocol are some of the most popularly used table-driven protocols.

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Reactive Protocols

Reactive protocols are on-demand routing protocols in the sense that routes are discovered only when a node wants to send a data packet. Route discovery and route maintenance are two main processes involved in reactive routing protocols. Dynamic Source Routing (DSR) and Ad Hoc On-Demand Distance Vector (AODV) are some of the most popularly used on-demand driven protocols.

Hybrid Protocols

Hybrid routing protocols combines the best features of proactive routing protocols and reactive routing protocols. . Hybrid routing protocol attempts to reduce control traffic overhead from proactive systems while reducing the route discovery delays of reactive systems by maintaining some form of routing table. Zone Routing Protocol (ZRP) and Sharp Hybrid Adaptive Routing Protocol (SHARP) are examples for hybrid protocols.

III. WHAT IS GENETIC ALGORITHMS

Genetic algorithms are searching algorithms used in computer science to find approximate solutions for optimization. GAs is meta-heuristic algorithm based on natural biological evolution. GAs is inspired by the principal of natural selection and fittest survival concept. Figure. 2 [14] describe Working Principle of Genetic Algorithms (GAs) such as:
Encoding is the mapping of problem solution fixed length strings called chromosomes. There are number of encoding schemes that can be used in GA such as binary encoding, octal encoding, value encoding etc. [5].

Initial population is a set of chromosomes where each chromosome is a fixed length of string.

Fitness evaluation is the evaluation of the fitness value of each chromosome. Each chromosome has a fitness value to be evaluated.

Selection is an important function in GA. Selection function selects best chromosomes from population with higher fitness values. Most commonly used selection techniques are roulette wheel selection, rank based selection etc.

Reproduction is the process during which new chromosomes are created. The first things that are very important in the creation of new chromosomes is called crossover or recombination and mutation operators.

Crossover operator is also called recombination operator which exchange genes from two chromosomes to produce new chromosome. The starting point and the length of portion to be exchanged are randomly selected. The new created chromosomes are put into the new population.

Mutation is also a genetic operator that alternate one or more bits in the string. Mutation helps the GA to search new chromosomes in new solution space.

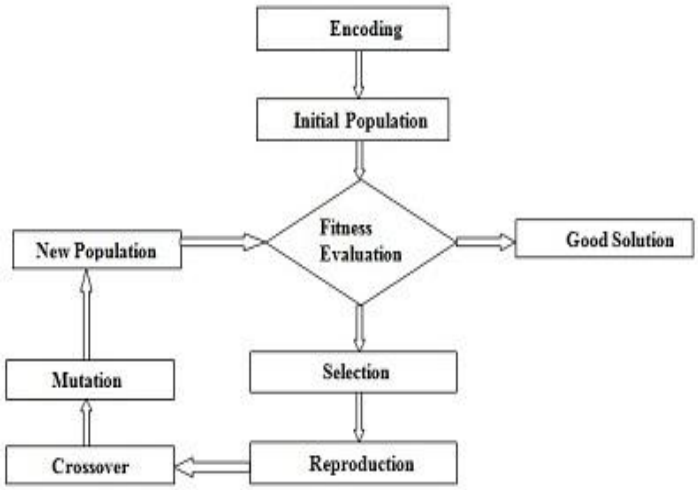

Figure. 2.
Genetic Algorithm

IV. QOS ROUTING FOR MANET

Quality of Service

Quality of service is a set of requirement services that network needs to be satisfied. The goal of QoS provisioning is to determine the network behavior so that the information carried by network can be better delivered and resources can be better utilized [18]. QoS provisioning can be seen over different layers in a protocol stack form physical layer to application layer. Each layer has the responsibility to take care of QoS requirements. There are number of QoS constraints such bandwidth, delay, reliability, jitter and cost. Quality of service needs to be guaranteed in real time wireless communication. Multicasting routing is used to communicate with one source and multiple destinations in a communication network [19]. For real time applications in communication network, multicast routing becomes increasingly popular. There are certain QoS constraints that should be satisfied by routing schemes [13]. So that the important element is QoS routing, which means routing based on QoS requirements. The main goal of QoS routing is to find path that satisfies multiple QoS metrics [22].Typical QoS metrics include available bandwidth, packet loss rate, estimated delay, packet jitter, hop count and path reliability. The main objectives of multicast quality of service routing are:-

1). to find multicast route from source to destination that support quality of service constraints.

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2). optimize the utilization of network resources.
3).computes the paths that are suitable for different type of traffic.

Genetic Algorithm based Quality of Service Multicast Routing

Basically, a genetic algorithm (GA) is a search technique used in computer science to find approximate solutions for optimization [2].So GA is used to improve quality of service in MANETs. Several GA based QoS routing techniques are proposed to support QoS in MANET networking. Genetic Algorithms (GAs) may be employed for heuristically approximating an optimal solution to a problem, in case quality of service routing finding the optimal route based on QoS constraints. The first stage of the process involves encoding multicast routes so that a GA can be applied, this is termed gene coding. Each chromosome in population denotes a multicast tree. So that a set of multicast routes becomes a candidate solution set. After the gene encoding and initial population the fitness value of each route is calculates through objective function. The fitness values are used to select paths for cross-over breeding and mutation operations. The fittest path and the offspring from the genetic operations are carried forward into the next generation. In this way finally we have set of routes from source to destinations that satisfy multiple quality of service parameters. Figure. 3 show how GA works for QoS multicast routing to support quality of service.

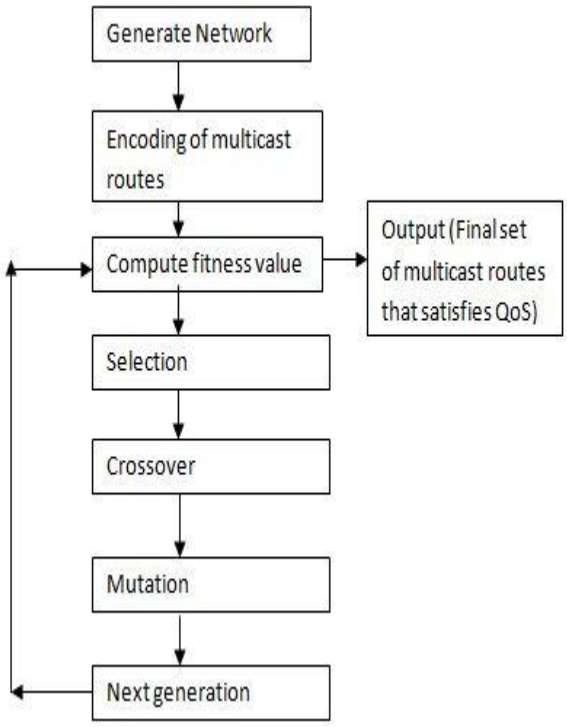

Figure. 3.
Genetic Algorithm for QoS multicast routing.

QoS Multicasting Routing Techniques based on Genetic Algorithm

From study of different algorithms it is concluded that there are a number of multicasting routing techniques based on GA for MANETs which have been evaluated on a given set of certain quality of services parameters by various researchers. Different routing techniques have different quality of service parameters. The following QoS multicast routing techniques based on Genetic Algorithms are explained below where each technique has its own different quality of service metrics to be guaranteed for which they have been designed.

Multicast routing with bandwidth and delay constraints based on genetic algorithms proposed in [11] find the multicast routes from a source to multiple destinations with bandwidth and delay constraints and optimizing theses parameters simultaneously to support quality of service. The proposed algorithm is able to find optimal solution and fast global convergence of solution.

The proposed algorithm based on GA considers four components:

(a) Encoding method is a genetic representation of chromosomes that are composed of routes that satisfies bandwidth constraint.

(b) Initial population is generated by randomly selecting shortest paths that satisfies bandwidth constraint.

(c) Objective function is to find a multicast tree T that satisfies:

1. Bandwidth constraint*:* $B(T) \geq B$.
2. Delay constraint: $D(T) \leq D$.

Suppose S(R) is the set and satisfies the conditions above, then, the required multicast tree T is: [11].

$$C(T) = \min(C(Ts); Ts \in S(R))$$

(d) Genetic operators include crossover that select two chromosomes and a cut point randomly and exchange the components of both the chromosomes based on cut point to produce a new chromosome and mutation is performed bit by bit manner according to mutation ratio(p_m).

Multiple constraints QoS multicast routing optimization algorithm in MANET based on GA [16] is an enhanced version of multiple constraints QoS multicast routing optimization algorithm in MANET (MQMGA). The proposed algorithm is able to optimize multiple constraints such as the maximum link utilization, the cost of multicast tree, the selection of long-life path, the average delay and the maximum end to end delay. The main objective of proposed algorithm is to find multicast tree T that satisfies following conditions: [16].

(i) Bandwidth constraint*:* $Bs \geq B$*;*
(ii) End-to-end delay constraint: $Ds \leq D$*;*

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(iii) Link capacity constraint: $(u + tij)/zij \leq 1$, "(i, j) Є *T*.

Suppose S(R) is the set and satisfies the conditions above, then, the required multicast tree T is: [16].

$$C(T) = \min(C(Ts); Ts \in S(R))$$

Genetic algorithms are searching techniques for optimization and based on natural evaluation. For multiple constraints quality of service optimization problems in MANET, genetic algorithms are efficient and robust for global optimal solution.

QoS Multicasting Routing Algorithm based on Immune Genetic method in NGN proposed in [10] is known as KIGAE that consider multiple constraints such as delay, delay jitter, bandwidth and packet loss. Next Generation Network (NGN) is a type of network which is different from existing network. NGN provide telecommunication services and quality of service enabled transport technologies. Genetic algorithms are heuristic algorithms inspired from biological evaluation. There are some drawback of GA such as incomplete convergence and weak local search ability. Therefore the proposed algorithm is based on improved immune genetic algorithm in NGN. The proposed algorithm is able to improve the method of establishing alternative path set using K-path label algorithm (KPLA), improves the genetic operators crossover, mutation and introduces the mechanism of judgment of local optimum and satisfies the demand of QoS multicast in NGN. This algorithm can provide global convergence and can jump from local optimum.

Multicasting Routing with Delay and Delay Variation Constraints Using Genetic Algorithm proposed in [17] is a genetic algorithm for delay and delay variation multicast routing (GADVM).This algorithm consider two constraints, first, end to end delay and second, delay variations from one source to each destination. Delay is critical and sensitive factor in multimedia applications. For multicast applications in a network, the proposed algorithm is able to find minimum Steiner tree, T, that satisfies the constraints, Path delay and Delay-variation The proposed algorithm has well performs in terms of failure rate and average cost per path metrics. GADVM has lower failure costs and its cost is also comparable better.

A Genetic Algorithm for Energy-Efficient based Multicast Routing in MANET proposed in [14] is an energy-efficient genetic algorithm that focused on energy consumption efficiency which generally means selecting the node with the minimum energy consumption in the route selection. MANET is a collection of wireless nodes that are depends on battery power which has limited energy for performing functionalities. Since the battery energy of a mobile node is finite and limited, if it drains the mobile node stops working and causing routing problems. So that the most important constraint is battery energy considered while developing energy efficient multicasting routing protocol. The proposed algorithm solves problems such as route load, battery life time in route selection, decreasing frequency of control messages and efficient route configuration techniques. This algorithm uses source tree based routing and consider shortest multicast path trees to minimize delay. In this algorithm a scheme is introduced to balance the battery energy consumption for multicast tree to provide maximum life time. Figure.4 [14] shows flowchart of energy-efficient genetic algorithm.

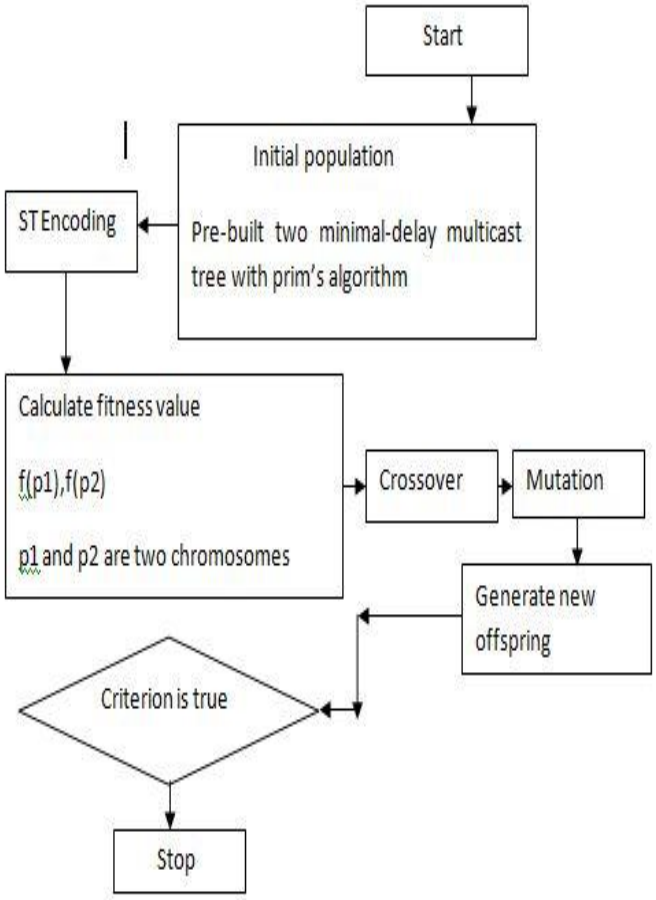

Figure. 4.
Flowchart of energy-efficient genetic algorithm

QoS Parameter Optimization using multi-objective Genetic Algorithm in Mantes proposed in [11] is based on multi-objective genetic algorithm (MOGA) to optimize quality of service parameters. A pareto-based MOGA can be used to optimize multiple QoS parameters in multicast routing. MOGA works on a set of populations to meet multi-objectives instead of single objective. Genetic algorithm is used to find multicast trees that are optimal and satisfies multiple quality of service parameters. The proposed algorithm optimizes the following QoS

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parameters such as delay, bandwidth, cost and battery capacity. The goal of multicast quality of service routing is to find optimal multicast tree that meets multiple quality of service objectives. In this way in proposed algorithm MOGA is applied to find optimal paths that paths that satisfy delay, bandwidth, and cost and battery capacity. Figure. 5 [11] shows outline of the proposed MOGA.

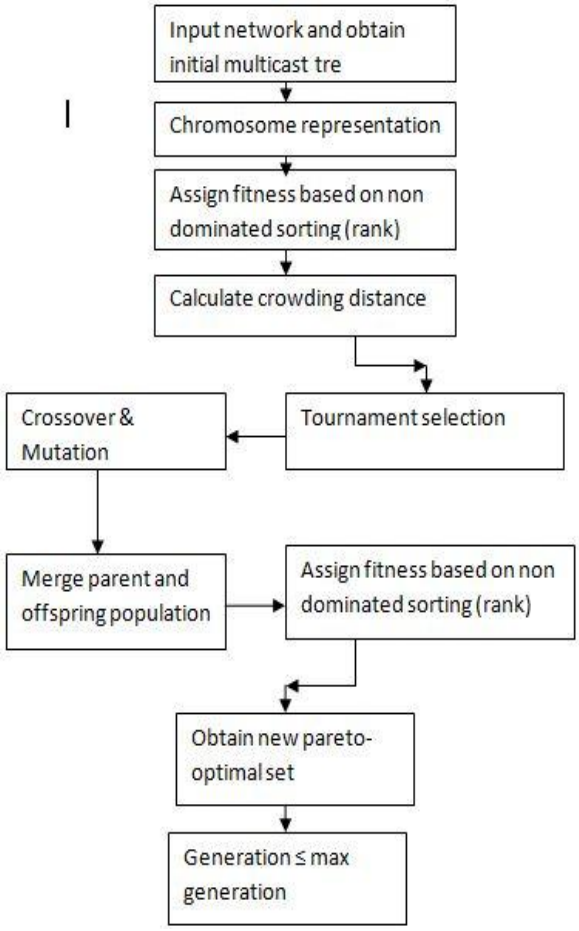

Figure. 5.
Outline of proposed MOGA

In Efficient Multi-objective QoS- Routing Algorithm for wireless Multicasting proposed in [20] has main objective to find optimal multicast routes that guarantees the strict QoS requirements. This algorithm uses non-dominated sorting based GA (NS-GA) to build an algorithm that can find optimal multicast routes that support multiple QoS objectives. Non-dominated sorting based genetic algorithm (NS-GA) is a variant of MOGA that optimize multiple parameters simultaneously. The quality of service parameters that are considered in that algorithm are end to end delay, bandwidth provisioning and bandwidth utilization**.** The proposed algorithm optimizes the quality of service parameters based on NS-GA that use some ranking techniques to rank the population based on non-domination of strings. The proposed algorithm has good performance and scalability while increasing the number of nodes and it optimizing all the three QoS parameters. Figure. 6 shows flowchart of proposed algorithm.

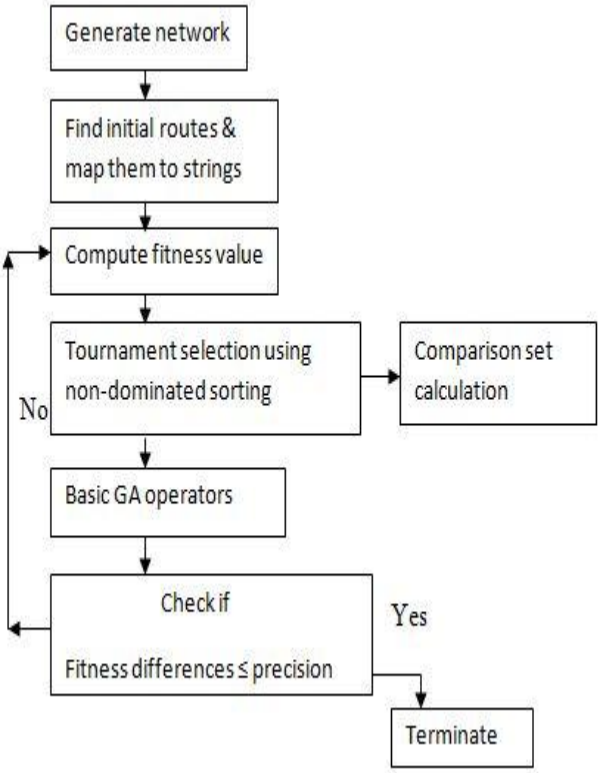

Figure. 6.
Flowchart of proposed Algorithm

A Multi-objective genetic algorithm based adaptive QoS routing in MANETs that the authors have proposed in [15]. The proposed algorithm uses MOGA to optimize multiple qualities of service parameters. MOGA can produce a set of optimal values where multiple individuals can search for multiple solutions in parallel manner. The algorithm is able to optimize four parameters bandwidth, hop count, delay and traffic from adjacent nodes. This GA based QoS routing is source based adaptive routing to support mobility of nodes and packets have less delay when the load on the network is high and

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when there is mobility of nodes change the topology. The GA works by combining the existing routes in order to generate new routes and select the optimal routes which are able to achieve the quality of service.

A Novel Fast Multi-Objective Evolutionary Algorithm for QoS Multicasting Routing in Manet proposed by authors in [13] is also known as QMOEA simplifies QoS multicast routing based on Core Based Tree Model (CBT). QMOEA absorbs the "greedy" and "family competition" approaches to speed up the convergence of algorithm and maintain the diversity of population. QMOEA has less running time and is able to achieve faster convergence. This algorithm optimizes four quality of service parameters bandwidth, delay, jitter and packet loss. The main objective of algorithm is that each path should be able to support these QoS metrics.

A Multi-objective model for QoS multicast routing based on genetic algorithm [19] is a multicast routing approach based on genetic algorithm using multi-objective model. The basic motivation of the modeling such approach based on an idea that it can be formulated as a multi-objective constrained combinational optimization problem for a protocol to determine routes satisfying the different QoS requirements. The major objective of routing based on genetic algorithm is to find that are good approximate to pareto optimal solutions. The proposed algorithm optimizes three QoS parameters delay, packet loss and jitter. multicast routes that satisfies multiple quality of service parameters and generate a non-dominated set of solutions

Tree-based genetic algorithm with binary encoding for QoS routing proposed by authors in [6] uses tree-based genetic algorithm (GA). Tree-based GAs represents the set of paths from source to destination as a tree and encodes them through the crossed junctions. e single paths in the chromosome. In this algorithm GA is designed with binary encoding that use junction based encoding model and represent classes of paths in each chromosome. The classes are composed of paths that are crossing the same junctions and are mutually exclusive and collectively exhaustive. For each such class local search is performed to find best path. Tree- based GA avoids the loops generation in the routes during the GA process, and the fixed-length of its chromosomes facilitates the genetic operations. Genetic operators such as crossover and mutation are applied on classes of paths rather than on single path. The genetic processing of classes and mutation probability helps the GA to converge faster.

Efficient hierarchical hybrid parallel genetic algorithm for shortest path routing proposed in [1] that is based on hierarchical hybrid parallel genetic algorithm for the shortest path routing. Genetic Algorithm (GA) can be parallelized because its algorithm process with a group of populations. The concept of parallel genetic algorithm (PGA) is to divide the task of the classical GA and divides on different processors. There are three types of PGA :(1) Master Slave Method (2) Fine-grained Parallel Genetic Algorithm (3) Coarse Grained Parallel Genetic Algorithm.

The proposed algorithm is a combination of coarse-grained genetic algorithm and fine grained genetic algorithm and to replace the genes it uses worst replace best migration scheme. In this algorithm the total population is divided into a set of subpopulation. The each subpopulation is run in parallel fashion and randomly elements are generated for each subpopulation. The algorithm has less time to choose shortest paths and reduces the communication overhead.

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V. QOS ANALYSIS

Approach	*Metrics*	*Method*	*Remarks*
Multicast Routing with Bandwidth and Delay Constraints based on Genetic Algorithm [8].	Bandwidth, Delay	Based on QoS metrics	Bandwidth and end to end delay taken into account.
Multiple constraints QoS multicast routing optimization algorithm in MANET based on GA [16].	Link utilization, cost, Selection of long life of path, average delay and delay.	Based on QoS metrics	Optimize multiple QoS constraints to support quality of service.
QOS Multicasting Routing Algorithm based on Immune Genetic method in NGN [10].	Delay, delay, jitter, Bandwidth and packet loss.	Based on QoS metrics	The algorithm is able to optimize multiple constraints to satisfy QoS requirements.
Multicasting Routing with Delay and Delay Variation Constraints Using Genetic Algorithm [17].	Delay and Delay jitter	Based on QoS metrics	Delay and Delay variation is taken as metrics.
A Genetic Algorithm for Energy-Efficient based Multicast Routing in MANET [14].	Energy consumption, Route Load, Battery Life Time.	Based on energy efficiency	Energy consumption and Battery Life Time taken into consideration.
QOS Parameter Optimization using multi-objective Genetic Algorithm in Mantes [11].	Delay, Bandwidth, Cost, Battery Capacity	Based on MOGA model	Time, cost and Battery Power constraints as metric.
An Efficient Multi-objective QOS- Routing Algorithm for wireless Multicasting proposed in [20].	End to End Delay, Bandwidth Provisioning and Bandwidth Utilization	Based on MOGA model	Time and Bandwidth constraints are taken as metric.
A Multi-objective Genetic Algorithm based Adaptive QoS Routing in Manet [15].	Bandwidth, Hop Count, Delay and Traffic.	Based on MOGA model	Hop count, bandwidth and Delay constraints are taken into account.
A Novel Fast Multi-Objective Evolutionary Algorithm for QOS Multicasting Routing in Manet (QMOEA) [13].	bandwidth, delay, jitter and packet loss	Based on MOGA model	Time, bandwidth and frequency constraints as metric.
A Multi-objective Model for QoS Multicast Routing based on Genetic Algorithm [19].	Delay, Packet loss and jitter	Based on MOGA model	Time constraints and frequency are taken into consideration.
Efficient Hierarchical Hybrid Parallel Genetic Algorithm for Shortest Path Routing [1].	Shortest Path	Based on Hierarchical hybrids parallel genetic Algorithm(PGA)	Take less time to choose shortest path and reduced communication overhead.
Tree-based Genetic Algorithm with Binary Encoding for QoS Routing [6].	Best Path	Based on Tree-based GA Model	Based on Binary encoding to choose best path.

Table (1) Quality of Service Multicast techniques based on Genetic Algorithms

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As shown in the table (1) each routing based on GA has own QoS metrics to be satisfied. QoS metrics satisfies two or multiple quality of service parameters such as multicast routing with bandwidth and delay constraints based on genetic algorithm satisfies delay and bandwidth and QoS multicasting routing algorithm based on immune genetic method in NGN satisfies delay, delay, jitter, bandwidth and packet loss. . Routing techniques based on MOGA use multi-objective model of GA to satisfy their own set of QoS constraints such as bandwidth, delay, jitter and packet loss. Routing scheme based on energy-efficiency parameter satisfies energy consumption requirement. The routing technique that is able to work on multiple QoS parameters can be considered best technique because that can provide strict QoS guarantee. Efficient hierarchical hybrid parallel genetic algorithm for shortest path routing is based on hierarchical hybrids parallel genetic algorithm (PGA) that finds shortest path in minimal time. Tree-based genetic algorithm with binary encoding for QoS routing is based on tree-based GA model that use binary encoding to choose best path from source to destination.

VI. CONCLUSION

This paper discusses how the Genetic Algorithm can be applied to implement multicast routing that satisfies Quality of Service constraints. The most commonly QoS parameters that are taken into account as metrics are: Bandwidth, Delay, Delay Variation and Cost. In Some algorithms the authors have considered bandwidth, delay, Packet loss and jitter as QoS metrics and some authors have taken into account energy consumption, cost and traffic load as additional constraints. To select an optimal route in MANET, it is necessary to consider maximum number of Quality of Service Parameters. To the best of our knowledge none of the existing algorithms has considered all the QoS parameters. Most of the authors have used two or three parameters as QoS metrics. So the objective of this paper is to find out the opportunity of research in this area. The future research work can be the development of new Genetic Algorithm based QoS routing techniques for MANET that consider Queuing delay, Bandwidth, Delay, Jitter, Packet loss delay, Buffer delay and Power aware constraint parameters.

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