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A Survey on Soft Computing Techniques for Multi-Constrained QoS Routing in MANET

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Abstract—**Mobile Ad-hoc Networks (MANETs) is a collection of mobile nodes that dynamically create a wireless network amongst them without using any infrastructure. Due to resource constraints and dynamic topology, supporting Quality of Service (QoS) in MANETs is a challenging task. The problem of QoS routing is difficult and to find a feasible route multi-constraints is NP-Complete problem. Neural Networks (NNs) and Evolutionary algorithms promise solutions to such complicated problems, they have been used successfully in various practical applications. In order to provide a comprehensive understanding of the solutions designed for MANETs and their related issues and to pave way for further research, a survey of QoS concept on the basis of disparate routing schemes, intelligence field including Neural Networks and Evolutionary Algorithm concepts has been discussed.**

***Index Terms*— MANETs, QoS, Routing protocols, multicast routing protocols, Genetic Algorithm, Neural Network, Evolutionary Technique, Fuzzy Logic.**

I. INTRODUCTION

Mobile Ad hoc Networks (MANETs) are typically heterogeneous network with various types of mobile nodes. Qualities of Service (QoS) parameters are mostly bandwidth, delay, jitter, and packet loss.QoS is more difficult to guarantee in MANETs than in other types of networks for the following reasons. First, the absences of a fixed structure coupled with the ability of node to move freely cause frequent route breakage and unpredictable topology changes. Second, the limited bandwidth resource is usually shared among adjacent nodes due to the wireless medium. Third, the nodes have limited power abilities.

In military applications, different military units ranging from soldiers to tanks can come together, hence forming an ad hoc network. In conference applications, different types of mobile devices such as Personal Digital Assistants (PDAs), smart badges, and laptops may exist in the ad hoc network at the same time. In most of these environments, various kinds of application are run which needs different levels of quality. Qualities of Service (QoS) parameters are mostly bandwidth, delay, jitter, and packet loss.

Numerous routing protocols were proposed to solve the routing problem in MANETs, primarily with no QoS guarantees [1, 2, 3, 4]. A comprehensive survey on the traditional routing protocols in MANETs can be found in [5]. Most routing protocols proposed to date purely function on the best effort basis with no attempt to provide any QoS requirement. Routing can inform a source node of the bandwidth and QoS availability of a destination node [6]. Thus QoS is a guarantee by the network to satisfy a set of predetermined service performance constraints for the user in terms of the end-to-end delay statistics, available bandwidth, probability of packet loss, and so on.

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A. QOS Support (Issues and Pitfalls)

Evolving of applications and the widespread use of wireless and mobile devices, it is desirable to support QoS in MANETs. Due to the resource limitations and variability further adds to the need for QoS support in MANETs make very complex process [1, 8, 9]. QoS is usually defined as the set of service requirements that need to be met by the network while transporting a packet stream from a source to a destination. Power consumption and service coverage area are two other QoS attributes that are more specific to MANETs [8].

B. Multi-constraints QoS

Multi-constrained quality-of-service (QoS) routing deals with finding routes that satisfy multiple independent QoS constraints. This problem is NP-hardThe multi-constraints QoS aim at optimizing multiple QoS metrics while provisioning network resources, and is an admittedly complex problem [10]. To support QoS, the link state information such as delay, bandwidth, cost, loss rate, and error rate in the network should be available and measurable. Some of the issues and difficulties for supporting QoS in MANETs [7] are Unpredictable Link Properties, Node Mobility, Limited Battery Life, Hidden and Exposed Terminal Problem, Route Maintenance and Security.

These entire issues make provisioning QoS functionality in MANETs a challenging task. It is observed that the QoS techniques which perform better in wired environment cannot perform better in wireless environment. This is due to the peculiar nature of wireless media, and the existing methods assume the protocol layering where layers functionalities are almost independent [11]. In wireless networks, layers cannot function efficiently in isolation without interaction with other layers. This leads to a possible cross layer approaches to provide network services like QoS.

The remainder of this paper is organized as follows. In section II we present a basic research on unicast and multicast routing protocols. In section III, introduction to another solution of intelligence concept Genetic Algorithm is given. Section IV elucidates another knowledge based solution for path routing with respect to MANET i.e. ‘Neural Network in simulation of QoS routing in MANET’. Above sections basically yields to a comparative study of disparate ways for enhancing the QoS in MANET. In section V, we present a comparison between NNs and GAs as far as MANET QoS routing is concerned. Section VI proposes the future work can be carried out for enhancing QoS metric in MANETs. Finally, in the last Section VII, we conclude the survey by presenting the sum and the substance of the routing philosophies, routing metrics and primary routing selection principles.

II. ROUTING PROTOCOLS

A. Routing protocols concept

In particular, it is important that routing protocols incorporate QoS metrics in route finding and maintenance to support end-to-end QoS. The issues involved with QoS-aware routing and present an overview and comparison of existing QoS-aware routing protocols are presented with an overview in this paper. Routing is used to set up and maintain routes between nodes to support data transmission. Early MANET routing protocols focused on finding a feasible route from a source to a destination, without any consideration for optimizing the utilization of network resources or for supporting specific application requirements. To support QoS, the essential problem is to find a route with sufficient available resources to meet the QoS constraints and possibly to incorporate optimizations, such as finding the lowest cost or most stable of the routes that meet the QoS constraints. Given these goals, the following are the basic design considerations for a QoS-aware routing protocol.

Given these goals, the following are the basic design considerations for a QoS-aware routing protocol [5].

- Resource estimation
- Route Discovery
- Resource Reservation
- Route Maintenance
- Route Selection
- Choosing routes with the largest available bandwidth (or minimum delay)
- Providing a call admission feature to deny route requests if insufficient bandwidth is available to support the request,
- Providing feedback to the application about available bandwidth resources or route delay estimation

Although there are already a few surveys in the area and some of them are even cited by this paper itself, some of them are out of date. The primary goal is to provide a useful taxonomy of the field of multicast routing protocol, identify those basic components of a multicast routing protocol, break them down into the necessary separate mechanisms, and categorize properties. Discuss the mechanisms need to provide in order to fulfill its function for the multicast routing protocol.

B. Multicast Routing Protocols

MANET is composed of MNs without any infrastructure and MNs self organize to form a network over radio links. In this environment, multicast routing protocols are faced with the challenge of producing multi-hop routing under host mobility and bandwidth constraint. Various multicast routing protocols with distinguishing feature have been newly proposed [12, 13]. A communication session is achieved either through single-hop transmission if the recipient is within the transmission range of the source node, or by relaying through intermediate nodes otherwise. For this reason, MANETs are also called multi-hop packet radio network [14, 15]. It is impossible to say which routing protocol is better for a given condition. Hence, the motivation is to group these multicast routing protocols under different routing strategies or categories and then compare these strategies.

It is surprise to found that, based on their primary routing selection principle, all of these protocols can be grouped into different categories of routing strategies depending upon their behaviour. Figure 1 depicts the hierarchy of the multicast routing protocols. So, the results presented in this section of the survey can be used by the research community and this can lead to a new paradigm for the comparison of multicast routing protocols [14].

C. Delay Aware Routing Protocols Techniques

In this section, Delay aware routing protocols for MANET are examined. The delay on discovered links during path discovery is considered as the main metric in path selection from source to destination in delay aware routing protocols. Further details have been mentioned in the paper [17]. Table 1a and 1b carves out the comparative study of all the different delay aware routing protocols along with their merits, demerits and the approach of evaluation i.e. the additional matrices and parameters that leads to the establishment of each and every protocol.

D. QoS for MANET on Border Gateway Protocol

Besides various QoS routing techniques designed for MANET, implementing Border Gateway Protocol (BGP) route exchange technique is also an efficient method various security techniques for this level have been designed. Security techniques like Cryptographic, Database, overlay/group Protocol, penalty, data-plane testing etc. This survey provides a basis for evaluation of the techniques to understand coverage of published works as well as to determine the best avenues for the future research. Primary Key Interface (PKI) [27] provides the mechanism to maintain the cryptographic keys needed in a solution. Although the use of PKI and databases has been present for over the last ten to twenty years, recent works have started to explore new directions, such as non-database overlay/group protocols, and data-plane testing techniques. These new techniques have several characteristics in common: they do not require an oracle and they do not require extensive cryptographic support. This can make them easier to deploy incrementally.

These techniques require more network resources, and unfortunately they still do not deliver high certainty about the validity of a routing update. BGP technique is considered to be a better option for orchestrating MANET because BGP security strategy aims to deliver the following

- High certainty of route validity
- Low router overhead, and
- Minimal impact on BGP route stabilization

If these attributes can be met, then deployed BGP will be able to move to the next level in assurance as far as MANETs are concerned [28].

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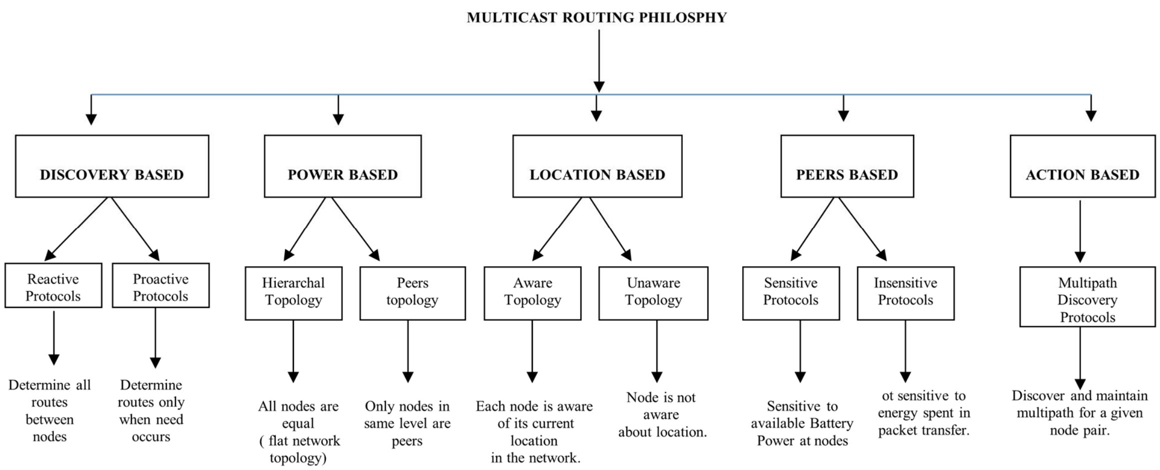

Fig. 1. Multicast Routing Philosophy.

TABLE 1A: REACTIVE ROUTING PROTOCOL CLASS

Protocols	Added Metrics	Simulation	Kind of Delay	Merits	Demerits	Evaluation
QoS-AODV [18]	Delay, Bandwidth	N/A	End-to-End	Maximum Jitter metric added, yields information about cumulative jitter experienced by nodes along the path	Security considerations not included.	Four fields added to routing table entry – • Maximum Delay, • Minimum Available Bandwidth, List of Sources requesting - • Delay Guarantees • Bandwidth Guarantees.
DAAM (Delay Aware AODV Multipath) [19]	Delay, Multipath	OPNET	End-to-End	Manages acceptable delay among other protocols including AODV.	Route delay information might not be always up-to-date.	Configures two scenarios – Static & Mobile
EDC-AODV (Energy and Delay Constrained) [20]	Delay, Energy	ns2	Current size of queues	Performs better than AODV due to inclusion of new metric 'Buffer Information' for finding the path.	Performs better only with respect to End-to-End delay.	Two new parameters – Residual Battery Power and Current Size of Queue.
EDAODV [17]	Delay, Energy	ns2	End-to-End	Provides better performance .	Works on Routing layer yields only route specific information.	Metrics added – • Packet Delivery ratio • End-to-End delay • Remaining Energy
EDDSR [21]	Delay, Energy	ns2	End-to-End	Better functionality than original DSR.	It also works on Routing Layer. (Study recommends use of MAC Layer)	Metrics added – • Packet Delivery ratio • End-to-End delay • Remaining Energy
SMR (Split Multipath Routing)[22]	Delay, Multipath	GloMo Sim	End-to-End	Better performance than DSR when packet loss is regarded.	Complex as includes multiple path selection.	Metrics enhances degree of avoidance of– • Congestion • Route Recovery

TABLE 1B: PROACTIVE ROUTING PROTOCOL CLASS

Protocols	Added Metrics	Simulation	Kind of Delay	Merits	Demerits	Evaluation
OLSR (Optimized Link State Routing) [23]	Delay	N/A	Media Access delay	Yields minimum hop path between source & destination nodes without link quality.	Performance not upto the mark.	Considers • Links Delay Metrics • Min-hop These enhance performance.
QOLSR (QoS scheme over OLSR) [24]	Delay, Bandwidth	OPNET	Average delay	High performance than OLSR.	Requires other QoS metrics to be used—Jitter & Packet Loss	Evaluates :Measured delay includes • Transmission time, • Queuing time, • Collision avoidance • Control overhead time.
OLSR_NN (OLSR with Neural Network) [25]	Delay	NS2	Mean Queuing Delay	Reduces end-to-end delay, Increases Data Packed Delivery Ratio.	Advanced Neural Network Technology needs to be implemented.	Evaluates -- Mean Queuing Delay using Neural Network methods.
LQOLSR (Link Quality aware OLSR) [26]	Delay	Real Impleme nta-tion	Packet Transmi-ssion Delay	Hop count is greater than OLSR so yields higher quality metrics.	Tested in real implementation environment but still not as efficient as QoS routing protocols.	Parameter: MATE (Mobility adaptive Transmission Rate) represents delay & calculated using Mobility Adaptive Delivery Rate (MAPDR).

III. GENETIC ALGORITHM APPROACH TOWARDS MANET

Shortest path routing is the type of routing widely used in computer networks nowadays. Even though shortest path routing algorithms are well established, other alternative methods may have their own advantages. One such alternative is to use a GA-based routing algorithm. GA-based routing algorithm has been found to be more scalable and insensitive to variations in network topologies [29]. Despite the existence of shortest path routing algorithms which are already well established, there are researchers who are trying to find alternative methods and one universally accepted method is to use genetic algorithm (GA). GA is a multi-purpose search and optimization algorithm that is inspired by the theory of genetics and natural selection. The problem to be solved using GA is encoded as a chromosome that consists of several genes. The solution of the problem is represented by a group of chromosomes referred to as a population.

In each iteration of the algorithm, the chromosomes in the population will undergo one or more genetic operations such as crossover and mutation. The result of the genetic operations will become the next generations of the solution. This process continues until either the solution is found or a certain termination condition is met. The idea behind GA is to have the chromosomes in the population to slowly converge to an optimal solution. At the same time, the algorithm is supposed to maintain enough diversity so that it can search a large search space. It is the combination of these two characteristics that makes GA a good search and optimization algorithm [30].

In this paper, highlight the different methods based on GA for solving the SP routing problem. One of the earliest GA-based shortest path routing algorithms is the one proposed by Munetomo et al. [31, 32]. Munetomo proposed a GA-based routing algorithm to generate alternate paths that can be quickly used in the case of link failures. This algorithm employs crossover, mutation and migration genetic operators in generating the next generation of solutions. Chang et. al [33] also proposed a GA-based routing algorithm for solving the shortest path routing problem. Similar to Munetomo's algorithm, the chromosome in this algorithm consists of a sequence of node IDs that are on the path from source to destination. Some researchers implemented a hybrid GA algorithm where GA is combined with another algorithm to solve the shortest path routing problem. One example of this is the algorithm proposed by Hamdan et. al [34] who combined GA with the Hopfield network. Another example would be an algorithm proposed by Riedl [35] who combined GA with a local heuristics search.

A. GAs for Shortest Path Routing

IN MULTI HOP networks, such as the Internet and the Mobile Ad-hoc Networks, routing is one of the most important issues that have a significant impact on the network's performance [36, 37]. An ideal routing algorithm should strive to find an optimum path for packet transmission within a specified time so as to satisfy the Quality of Service (QoS) [37, 38, 39]. There are several search algorithms for the shortest path (SP) problem: the breadth-first search algorithm, the Dijkstra algorithm and the Bellman–Ford algorithm, to name a few [36]. SP problems in polynomial time, they will be effective in fixed infrastructure wireless or wired networks. But,unacceptably high computational complexity for real-time communications involving rapidly changing network topologies [38, 39].

In [37] MANEs as target systems because they represent new generation wireless networks. The nodes cooperatively maintain network connectivity without the aid of any fixed infrastructure networks, dynamic changes in network topology are possible. An optimal (shortest) path has to be computed within a very short time (i.e., few s) in order to support time-constrained service such as voice-, video-, and teleconferencing [39]. The indicated algorithms do not satisfy this (real-time) requirement. Investigators have applied GAs to the SP routing problem multicasting routing problem.

Problems like ATM bandwidth allocation problem, capacity and flow assignment (CFA) problem and the dynamic routing problem are combinatorial optimization problem.

A new GA for solving the SP routing problem has been proposed in the paper [40] in which the crossover and mutation operations work on the variable-length chromosomes. Simulation studies shows that the algorithm is indeed insensitive to variations in network topologies in respect of both route optimality (quality of solution) and convergence speed. The computational time of this GA is shorter than that of others like Dijktra's algorithm. In addition to this, it can also search the solution space effectively and specially compared with other extant algorithms.

B. GA Based multipurpose optimization algorithm for QoS Routing

The routing algorithms need to serve two types of network scenarios. To cope up with the Broadband Networks the algorithms should give a fast decision and must be adaptive, flexible and intelligent for efficient network management.

1) For Broadband Networks

Two major concepts used in Broadband Networks are Genetic Load Balancing Routing (GLBR) is proposed in paper [41, 42, 42]. This adaptive routing mechanism has a load balancing system among alternative paths. The individual genes are used to express the connected nodes of a route. Adaptive Routing method based on GA (ARGA) [42, 43] is basically a novel gene coding method, the chromosomes have the same length, which results in easy genetic operations and a fast routing decision can be achieved. So, the genetic operations are carried out in the tree junctions, so the searched route always exists. Secondly in ARGA, the genes in a chromosome have two states 'active' and 'inactive'. A gene is called 'active' if the junction is in the route else the gene is in 'inactive' state.

Table 2a shows the routing hierarchy for Broadband Networks thereby indicating several routing options with their pros and cons over one another. COMMON PROBLEM with above methods is that all of them use only 'DELAY' as the QoS parameter. SOLUTION For multimedia communication, the one in which multimedia data such as video, audio, graphics, text files are transferred, the routing algorithms should use more than one QoS parameter such as throughput, delay and loss probability. This is because new services video on demand requires better QoS.

2) For Multimedia Networks

Major concept based on GA is simulated as Adaptive Routing method based on GA with QoS support (ARGAQ) is a GA based routing algorithm. The distributed applications have very diverse QoS constraints on delay, loss ratio and bandwidth. Multiple constraints often make the routing problems intractable. For instance, finding a feasible route with two independent path constraints is NP-Complete [44].Any future integrated service network is likely to carry both QoS traffic and best-effort traffic, which makes the issue of performance optimization quite intricate.

- The network state changes dynamically due to transient load fluctuation, connections in and out, and links up and down.
- The growing network size makes it increasingly herculean task to gather updated state information in a dynamic environment.

The performance of QoS routing algorithm can be acutely degraded if the state information is obsolete. For the above reasons, fast and expeditious QoS algorithms are required to support multimedia transmission. Table 2b gives a comparative study of different routing options for two types of networks.

3) Multi-purpose Optimization algorithm

It's a Genetic algorithm based algorithm for QoS routing. It uses a multi division group model for multipurpose optimization. When a purpose function can be divided into various purpose functions then global domain can be divided into different domains and each individual can evolve in its domain [45]. The method finds a route if the individual satisfies the end conditions. In this cast the individual is selected as the optimized route. If an optimal route can't be found then the best individuals are traded-off between each domain. This procedure is carried out until the number of generations is achieved.

C. Parallel Genetic Algorithm Approach

It is also known that GA-based routing algorithm is not fast enough for real-time computation. In this paper, we proposed a parallel genetic algorithm for solving the shortest path routing problem with the aim to reduce its computation time [44]. GA is generally able to find good solutions in reasonable amount of time but as they are applied to harder and herculean problems, there is an increase in the time required to compute adequate solutions. To tackle this problem, there have been multiple efforts to make GA faster and one of the promising choices to use parallel implementation [45].

In parallel GA (PGA), there are multiple computing nodes. The task of each computing node depends on the type of parallel GA used. There are four major types of parallel GAs: (1) Master-slave GA, (2) Coarse-grained GA, (3) Fine-grained GA and (4) Hierarchical hybrids.

- In master-slave GA, one computing node will become the master and the other computing nodes will become the slaves.
- In coarse-grained GA, the population is divided to the computing nodes. Each computing node would then have a sub-population and each node executes GA on its own sub-population.
- Fine-grained GA has the highest level of parallelism among the four types of parallel GAs. But it also has a large communication overhead due to the high frequency of interactions between neighbouring nodes.

The other implementation and entire parallel genetic algorithm for shortest path routing has been elucidated in paper [30]. In addition to this the applications of parallel GA has been successfully used in various problems such as design optimization [46], transport routing [47], time series forecasting [48], network design [49] and sorting [50].

TABLE 2A: ROUTING HIERARCHY FOR BROADBAND NETWORKS

GLBR	SPF	RIP	ARGA
Genetic Load Balancing Routing Better performance than others. Using it causes problems in Gene Coding method. Methodology- Genes put in a chromosome in the same order the nodes from the communication route. Validity check- Of the searched routes is imperative.	Shortest Path First Routing Gathers kink state information from available routers and constructs topology map of network. Uses only 'Delay' as the QoS parameter. Reduces efficiency.	Routing Information Protocol A Distance Vector Routing protocol employs the hop count as routing metric. It also uses only 'Delay' as the QoS parameter. Reduces efficiency.	Adaptive Routing Method based on GA Faster routing decision than GLBR. Solution to the pitfalls of GLBR. Methodology – Network modeled in a tree, Genes expressed as the tree junctions. Validity Check- Of the searched routes is not necessary.

TABLE 2 B: COMPARISON OF DIFFERENT ROUTING OPTIONS

Broadband Network Concepts	Multimedia Communication Concept
GLBR and ARGA methods -Use only one QoS parameter i.e. DELAY - Not upto the mark performance.	ARGAQ method Uses two parameters :DT (Delay Time) TSR (Transmission Success Rate) Good performance and promising method for QoS routing

IV. NEURAL NETWORK BASED APPROACH FOR MANET

A. *Evolution of Neural Network Approaches*

The solution extends the traditional single layer recurrent Hopfield architecture introducing a two-layer architecture that automatically guarantees an entire set of constraints held by any valid solution to the shortest path problem. Problems that require multiple or extremely fast computations of SP (shortest path), such as quasi-static bifurcated routing problem in packet switched networks [51] can benefit from more efficient methods of finding the SP. Motivated by this case of problems, a number of attempts using neural networks, namely Hopfield Neural Networks(HNNs) [52], were made to solve or provide an approximate solution to the SP problem faster than would be possible with any algorithmic solution, relying on the Neural Networks(NNs) parallel architecture. Table 3 is a survey embodying the comparative study of different algorithms based on Neural Network.

Another solution to above problems is a new Hopfield NNs, called as Dependent Variable Hopfield Neural Networks (DVHNNs) aims at improving the reliability of the solutions [53] .Here reliability stands for succeeded and valid convergence. To attain this, a new architecture named Dependent Variables (DV), which consists of two layers HNNs is presented. This architecture automatically guarantees an entire class of restrictions, thus considerably increasing the reliability of the method. At the same time the number of neurons is equal to the number of arcs in the graph instead of being equal to the squared number of nodes as it is the case in Ali-Kamoun's [54] and Park-Choi's [37] NNs. Thus, in general, the architecture needs much less neurons and neurons' connections.

The papers released in previous years [1, 3, 5, 6, 7, 8], some approaches have been developed for addressing at different levels, the problem of QoS provisioning in MANETs. These approaches have been elucidated in the Table 4.

Later on [58], an intelligent quality of service (QoS) model named GQOS, with service differentiation based on neural networks in mobile ad hoc networks. The model is composed of two plans: GQOS kernel plan and the intelligent learning plan. The kernel plan ensures basic functions of routing and QoS support control, and an intelligent learning plan ensures the training of GQOS kernel operations by using a neural network. The applied Multilayered Feed forward neural networks (MFNNs) allows a fast learning of different operations performed by the kernel and permits a reduction of the processing time in the network. To regulate traffic, a flexible priority queuing mechanism is introduced in the kernel. The detailed information about the model can be gathered from [58].

A. *Neural Networks approach for real-time operation*

In the year 2008, a neural network approach named shortest path neural networks (SP-NNs) is proposed for real time online path planning. Path planning is a crucial and an indispensible topic for robot navigation. Some methods like artificial potential field (APF) method [59], vector field histogram (VFH) and behavior-based path planning methods do have good performance in simple environments with a relatively low computational cost [60]. However, they suffer from undesired local minima sometimes and generally the generated path is not a global shortest.

TABLE 3: EVOLUTION OF NEURAL NETWORK BASED ROUTING ALGORITHM SOLUTIONS

AUTHORS OF ALGORITHM	LIMITATIONS OF ALGORITHM PROPOSED	ADVANTAGE OF ALGORITHM PROPSED
Rauch and Winarske [56]	Need to know the number of hops required for shortest path in advance.	First development towards the field of NN based routing solutions.
Zhang and Thomopoulos [57]	Not adaptable to external conditions	Finds a path with as many as N hops (N= No. of nodes in graph = Max. no. of hops SP can have)
Ali and Kamoun [37]	NN fails to converge towards a valid solution a no. of times. Above problem intensifies as no. of nodes in graph increases.	Aims at the NN adaptability to external varying conditions.
Park and Choi [55]	Fails to coverage too many times. Poorer behavior with increasing no. of graph nodes.	Multi Destination routing problem. Single Destination routing version – Here extends the range of operation of former method.

TABLE 4: QOS APPROACH BASED ON NEURAL NETWORKS

FQMM	NSIGNIA	SWAN
Hybrid approach combining advantages of per-class granularity of DiffServ with per-flow granularity of IntServ. Preserves per-flow granularity for a small portion of traffic in MANETs. Good solution for small and medium size adhoc networks. Not suitable for large networks.	Requires per-flow granularity in adhoc networks. Provides adaptive QoS guarantees for real time traffic. In-band signaling system supporting reservation, restoration and adaption algorithms. Considers only Bandwidth qoS parameter.	Uses Distributed Control Algorithms. Relies on feedback from MAC Layer as a measure of congestion in network. Provides rate control system to treat traffic either as real-time or best-effort traffic. Demerit is how to calculate the threshold rate limiting any excessive delay experienced.

Neural network approaches that have been proposed in the recent years are discussed in Table 5 and this table highlights the variation in the concepts thus evolved [61]. This paper introduces a model called as SP-NNs for path planning. In this, neurons are only locally connected to its neighbours. Extensive simulations reveal the effectiveness of this model. Also, SP-NNs can recognize the situation with no free path from start to the goal according to the state value of the neuron corresponding to the start position.

B. *Dual NN for SP*

The shortest path problem is a classical combinatorial optimization problem arising in numerous planning and designing contexts. In [70] considered another NNs based method have a recurrent neural network called the Dual Routing network which has a simpler architecture.

The well known algorithms for solving the shortest path problem include the following [70].

- $O(n^2)$ Bellman's Dynamic Programming algorithm for Directed Acyclic Networks,
- $O(n^2)$ Dijkstra-like labeling algorithm,
- $O(n^3)$ Bellman-Ford successive approximation algorithm for networks nonnegative cost coefficients only, where 'n' denotes the number of vertices in the network and Breadth First Search (BFS) algorithm for path routing.

This investigation shows the sufficient potentials for the neural network approach to the shortest path problem. The Dual Routing network with $O(n)$ neurons and $O(n^2)$ connections is capable of shortest path routing for directed networks. Since the solution process is inherently parallel and distributed, the convergence rate is not decreasing in nature with respect to the size of the shortest path problem. Furthermore, the convergence rate of this routing network can be expedited by properly scaling design parameters. Another salient feature of the Dual routing network is the independence of the connection weight matrix upon specific problems.

TABLE 5.: EVOLUTION OF NEURAL NETWORK APPROACHES

AUTHORS	CONCEPT PROPOSED
Siemiatkowska B[62,64]	Parallel Cellular Neural Network based model for path planning. Can find free path in unknown and varied environments.
R. Glasius and A. Komoda Komoda [64,65]	Discrete neural network model and a Continuous neural network model for path planning. Applied this to two-linked manipulator motion planning.
Yang and Meng [66,67]	Biological inspired neural network approach for path planning. More robust and more powerful.
Willms and Yang [68,69]	Simple and efficient Dynamic Programming (DP) shortest path algorithm for path planning. Generated path is globally shortest.

V. COMPARISON OF GA AND NNS IN MANET

The following table Table 6 and Table 7 show the comparative study and similarities respectively between Neural Networks [71] and Genetic Algorithm Concepts with respect to adhoc networks [40].

VI. CONCLUSION

Shortest path computation is one of the main concepts in the Graph theory. It has large number of applications. Routing in communication networks, vehicle routing problems and robot arm motion planning are few of them. Neural Networks [58,54,70,61,71], Genetic Algorithms [40,72,46,30] and other soft computing and metaheuristics

The survey shows that various QoS routing protocols with their simulation, NNs and GAs methods are good candidates for solving dynamic SP routing problems. This paper stands at the culmination of the entire study of QoS routing in MANET. With the support of pictorial diagrams and tabulations which have created a complete survey of all the contributions made, to the field of QoS routing in MANET.

algorithms are able to provide solutions for these types of intricate problems. These algorithms have been used efficiently and proved their capability of solving these types of complex problems in various practical applications. In this paper the concepts of dynamic SP routing problems were reviewed.

VII. FUTURE PROPOSAL

Till now, it has been observed that most of the existing solutions for maintaining the QoS parameter for networks suffered either from the excessive computational complexities or from the low performance. In addition to this, these solutions are mostly preferable for wired networks and cannot be used directly for wireless MANETs. So, the future work is focused on a new proposed method of multi-constrained routing based on Neuro-Fuzzy-Genetic algorithm that will solve the optimum routing problem for supporting QoS in adhoc networks and which will be known as NFGMAN technique (Neuro-Fuzzy-Genetic algorithm based approach).

The idea of NGMANET is to reduce the NP-complete problem to a simpler one, which can be solved in polynomial time. So that the neural network could be robust to change of network topology. The purpose of the QOS routing with multi-constraints algorithm is to find the optimal networks path from a single source to multi destination nodes for packet transmission within a specific time.

TABLE 7.: SIMILARITIES BETWEEN GA AND NN APPROACH IN MANET

Features	Neural Network and Genetic Algorithm
Iterations performed	Large in number
Hardware Implementations	Very fast in general
Insensitive To	Network size and Topologies

TABLE 6.: COMPARATIVE STUDY OF GA AND NN APPROACH IN MANET

Features	Neural Networks	Genetic Algorithms
Quality of solution returned (Computed path)	Inflexible with solution. Constraints by inhabitant traits	Flexible in regard of solution. Quality adjusted as a function of population.
Hardware	NN Hardware limited in size. Cannot accommodate networks of arbitrary size because of its physical limitation.	Scales well to networks that may not even fit within the memory. Real computation size doesn't increase very much as the network size expedites
Convergence speed	Provides comparatively less efficient convergences.	Insensitive to variations in network topology wrt convergence speed
Hybrid Forms	Used in hybrid manner with soft computing concepts to enhance solution space further for real time problems.	GA is combined with another algorithm to solve the shortest path routing problem.
Examples	Resource Allocation Graphs (RAN) Radial Basis Functions (RBF) networks	GA combined with Hopfield network, GA encapsulated with Local Heuristics search.

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