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The Application of Genetic Algorithm in the design of Routing Protocols in MANETs: A Survey

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***Abstract*— The mobile ad hoc network is a decentralized and self organized wireless network which does not work on any fixed infrastructure so it is having a time variant topology which varies time to time due to the mobility of the nodes. In the same way the natural world is enormous, dynamic, incredibly diverse, and highly complex. Despite the inherent challenges of surviving in such a world, biological organisms evolve, self-organize, self-repair, navigate, and flourish. Generally, they do so with only local knowledge and without any centralized control. Our Mobile Ad hoc networks are increasingly facing the similar challenges as they grow larger in size. Many research efforts have been made based on the Genetic Algorithms for the development of the various data routing techniques for MANETs. As a result, genetically inspired research in Mobile Ad hoc Networks is a quickly growing field. This survey paper begins by exploring why Genetics and MANETs research are such a natural match. We then present a broad overview of genetically inspired research in MANETs. We concluded how genetics concepts have been most successfully applied in MANETs.**

Keywords- MANETs; Genetic Algorithm; Gene; Genetics, MHs (Mobile Hosts), DOPs (Dynamic Optimization Problems), EAs (Evolutionary Algorithms), Shortest path tree (SPT), QoS.

I. INTRODUCTION

In the last 15[1] years, we have witnessed unprecedented growth of the Networks. The tremendous size and complexity that is associated with any large-scale, distributed system is pushing the limits of our ability to manage the networks. A mobile ad hoc network (MANET) [1] a self-organizing and self- configuring multi-hop wireless network ,which is comprised of a set of mobile hosts(MHs) that can move around freely and cooperate in relaying packets on behalf of one another. A MANET supports robust and efficient operations by incorporating the routing functionality into MHs .In multi-hop networks, routing is one of the most important issues that has a significant impact on the network's performance .In a MANET, each MH is a router and forwards packets on behalf of other nodes .Multi-hop forwarding paths are established for nodes beyond the direct wireless communication range. Routing protocols for MANETs must discover such paths and maintain connectivity when links in these paths break due to effects such as the node movement, battery drainage, radio propagation, and wireless interference.

There are broadly two categories of routing protocols [11]

1) *Topology based routing protocols*
   - *Proactive routing protocols (Table Driven root discovery)*
   - *Reactive routing protocols (On Demand root discovery)*
   - *Hybrid routing protocols*
2) *Position based routing protocols[11]*
   - *Greedy routing protocols (position based route discovery)*

In a MANET, the network topology keeps changing due to its inherent characteristics, such as the node mobility and energy conservation. Therefore, the route discovery problem in MANETs turns out to be a dynamic optimization problem (DOP). An effective route discovery algorithm should track the topological changes and adapt the best route tree to the changes accordingly. There are mainly two types of algorithms for the routing problem:

A. *The deterministic algorithms*
B. *The search heuristics. (Genetic Algorithms)*

For a given the route discovery request, only one route tree is constructed for a given topology by a deterministic algorithm, e.g., the shortest path tree (SPT) algorithm. However, by the search heuristics, such as genetic algorithms (GAs) and simulated annealing (SA) algorithms, lots of route trees are searched and the best one is selected as the final result. All the deterministic algorithms have polynomial time complexity. Therefore, they will be effective in fixed infrastructure wireless or wired networks. But, they show an unacceptably high computational complexity for real-time communications involving rapidly changing network topologies such as MANETs. Therefore, for the dynamic route discovery problem in a changing network environment, the search heuristics are worthy of investigation. In recent years, studying evolutionary algorithms (EAs) for DOPs has attracted a growing interest due to its importance in EA's real world applications. Over the years, several approaches have been developed for Genetic Algorithms to address dynamic environments, such as maintaining diversity during the run via random immigrants and increasing diversity after a change.

In this paper, we investigate several genetic algorithms that are developed to deal with general DOPs to solve the dynamic rout discovery problem in MANETs. The rest of this paper is organized as follows. Section II discusses the Genetic Algorithm. The Applications of Genetic Algorithm in protocol design are provided in Section III. Section IV summaries and concludes this paper.

II GENETIC ALGORITHM

The genetic algorithm [8] proposed by Holland in 1975 is derived from the ideas of natural selection and natural

genetic. Genetic algorithms are different from other heuristic methods. The most important difference is that:

1) A genetic algorithm works on a population of possible solutions, while other heuristic methods use a single solution in their iterations.
2) Another difference is that genetic algorithm is stochastic, not deterministic. Each individual in the genetic algorithm population represents a possible solution. Some individuals are selected based on the fitness value. And then, genetic algorithm imitates the nature genetic process, crossover, to exchange some of these individual genetic data randomly to generate the offspring.

By repeating these processes until the best genes, which have the fittest capability, are obtained. Each individual may represent one or more chromosomes with an associated fitness value and population. Genetic algorithm is also a searching algorithm that employs the ideas of natural selection and the genetic operators of crossover and mutation. In each generation, a new population of solutions is created by exchanging and combining the information obtained from the solutions of the previous generation. In genetic algorithm, the variables of the problem are like the genes in a chromosome. A context in each bit of string is called chromosome. One gene of a chromosome represents one possible solution. In general, the main operations of genetic algorithm are encoding, initial population, and evaluating fitness value, reproduction, crossover and mutation. A flowchart of a typical genetic algorithm is shown in Fig. 1.

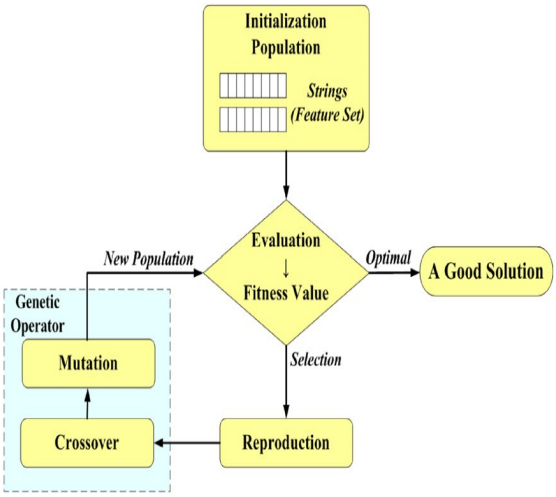

Fig. 1. The flowchart of a simple genetic algorithm

The selection is an evolutional operator in the genetic algorithm. It is also the policy for selecting the fittest individuals from the population. It will need a method to calculate this fitness. The fitness method simply calculates the amount of free space each individual/solution offers. The best is selected for further iteration. There are two main genetic operators in genetic algorithm. The first is the crossover and the other is the mutation. These two genetic operators allow the chromosomes to search for the global optimum through an evolutionary manner. The crossover is the method for combining those selected individuals into new individuals. The crossover splits up the ‘‘parent’’ individuals and recombines them. It is also one of the genetic operators in which genes of two chromosomes are exchanged and the genotypes of two selected parents are merged to yield two new offspring. Two chromosomes with greater fitness values are picked from the chromosomes pool. The starting point and length of the portion to be exchanged are randomly selected. The two new offspring are created and put back into the chromosomes pool. The mutation simply adds ‘‘genes’’ to the individuals (usually called ‘‘children’’). Mutation introduces new genetic structures in the population by randomly modifying some of the genes, such that the search algorithm can escape from the local optimum and avoid the genetic algorithm from converging too fast. In other words, mutation operation gives genetic algorithm an opportunity to search for new and more feasible chromosomes in new areas of the solution spaces. After the mutation operation, the multicast tree will be modified because of mutation operator can destroy the tree structure and outgoing degree constraints. A genetic algorithm has a number of advantages. It can quickly scan a huge solution set. Bad proposals do not affect the end solution negatively as they are simply discarded. The inductive nature of the genetic algorithm means that it does not have to know any rules of the problem. It works by its own internal rules. This is very useful for complex or loosely defined problems.

III. THE APPLICATIONS OF GENETIC ALGORITHM IN PROTOCOL DESIGN IN MANETS

In the last few years there are various GA based protocols design techniques have been suggested and implemented by the research community some of the proposed techniques are discussed below:

1) *Application of GA in solving the dynamic multicast problem in MANETs [9]:*
   In a MANET, [9] the network topology keeps changing due to its inherent characteristics such as the node mobility and energy conservation. Therefore, an effective multicast algorithm should track the topological changes and adapt the best multicast tree to the changes accordingly. So the use of genetic algorithms with immigrants schemes to solve the dynamic QoS multicast problem in MANETs. Extensive experiments are conducted based on both of the dynamic network models. The experimental results [9] show that these immigrants based genetic algorithms can quickly adapt to the environmental changes (i.e., the network topology changes) and produce high quality solutions following each change.
2) *Application of GA for energy-efficient based multicast routing on MANETs [7]:*
   In ad hoc networks, [7] mobile node battery energy is limited and is one of the important constraints for designing multicast routing protocols. An energy-efficient genetic algorithm mechanism to resolve these problems was proposed [7]. To design a source-tree-based routing algorithm and build the shortest-path multicast tree to minimize delay time by using a small population size in the genetic algorithm. Only a few nodes are involved in the route computation. The simulation results [7] show that the proposed method

based on GA is an efficient and robust algorithm for multicast route selection.

3) *Application of GA in routing optimization in Ad hoc Network s [5]:*
Ad hoc networks requires [5] a highly adoptive routing scheme to deal with the frequent topology changes. So the proposed [5] algorithm for improving routing in clustering algorithm based on both Clusterhead gateway switching protocol (CGSR) and the mechanisms of a genetic algorithm (GA).As the GA mechanisms allow for self configuration quickly and efficiently to adjust an ever changing local topology, thus initiating fewer link breakages. Also the proposed [5] Genetic algorithm shows that GA's are able to find if not the shortest, at least a very good path between source and destination nodes in MANETs

4) *Application of GA in QoS Route Selection for Mobile Ad -hoc Networks [4]:*
It is a challenging issue designing a QoS routing protocol [4] for mobile ad hoc networks. Because in selecting the most optimal route from source to destination, one has to select from a set of routes with corresponding connectivity qualities. The QoS routing scheme that selects a source to destination route using genetic algorithm such that the route need to satisfy the node bandwidth, node delay, end –to-end delay and node connectivity index. The simulation results [4] shows that QoS routing can successfully utilized GA in finding the optimal route.

5) *Application of GA for Path Bandwidth calculation in TDMA-based MANETs [3]:*
As the development of routing protocols for Mobile Ad Hoc Networks (MANETs) has become an important research field because of the promising applications provided by the MANETs. In a TDMA - based MANETs, routing protocols should be designed such that it meets the QoS constraints like bandwidth in addition to finding the shortest path. As most of the existing protocols concentrate only on finding the shortest path. Therefore with an aim to satisfy the QoS requirements by maximizing the path bandwidth found between the source and destination. Thus the efficient GA approach uses genetic algorithm to solve the problem of finding the path with maximum bandwidth.

6) *Application of GA based approach in Genetic Zone Routing Protocol (GZRP)[2]:*
GZRP [2] applies the Genetic Algorithm (GA) to Zone Routing Protocol (ZRP) for finding a limited set of multiple alternative routes to the destinations, in order to provide load balancing and fault tolerance during node or link failure by using the routing database available at the border nodes.

Thus we sum up few of the applications out of the various applications of the GA based Approach ,which is best suitable from the point of view of MANETs, in the design of routing protocols.

IV. SUMMERY AND COCLUSIONS

A number of research efforts have attempted to design self-organizing mobile networks based on Genetic Algorithms. A great deal of successful research in the field of Mobile Ad Hoc
Networks have been inspired by Genetic Algorithms. Yet, we believe genetically inspired mobile ad hoc networking still has
much room to grow. In particular, there are great opportunities
in exploring a new approach. Whether successful or not, current research tends to follow the same general philosophy[1]:

- Observe some high-level behavior in nature which has a direct parallel to a desirable behavior for mobile ad hoc networks (MANETs).
- Explore the basic biology of this behavior – what individual components make up the system, the processes these components perform, what mathematical models have been used to describe this behavior, and so on.
- Look for components, processes, or models that seem like they could map well to the computer networking domain.
- Turn these components, processes, or models into algorithms, new mathematical models, or software implementations. Generally attempt to stay as close as possible to the biological

Therefore, the goal of bio-inspired research should be to find broader lessons and principles in the way large biological systems are built, then determine how to apply these lessons and principles to the design of networked systems such as MANETs.

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