A Survey on Energy Efficient Routing In MANETs Using Multi-Objective Genetic Algorithm

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***Abstract*—** Mobile ad hoc networks (MANET) are self-establishing network that contains short radio range and limited bandwidth and they do not have any specified infrastructure. The ad hoc network changes its topology suddenly. In such this type of situation, establishing correct and efficient routes from source to destination is an important design issue in mobile ad hoc networks and its challenging goal is to provide energy efficient routing protocol. For finding the shortest path between the sources to destination, the routing technique genetic algorithm (GA) plays an important role. Such type of routing technique will reduce in finding the route again and again when any failure occurs in the path. Hence, it will take less time in sending again the packet to the destination and therefore it results in increasing throughput in the Mobile Ad hoc Network. In this paper, we have discussed the routing protocols, its classifications, advantage and disadvantages of the routing protocols and taxonomy of energy efficient routing protocols in Mobile Ad hoc network.

Keywords*—MANETs, Routing Protocols, Energy Efficient Routing Protocols, Genetic Algorithm*

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I. INTRODUCTION

Mobile Ad hoc Network (MANET) are the autonomous system that contains mobile nodes. Each node in the network communicates with each other using wireless communication. Ad hoc network do not have any former infrastructure i.e. they are infrastructure less in nature [1]. They interact with each other directly or indirectly with intermediate nodes [3]. An example is shown in Figure 1.

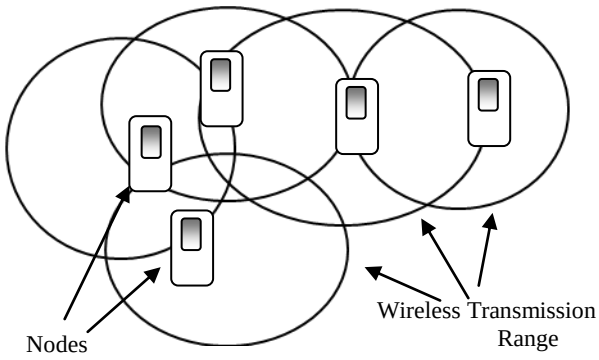

Figure 1. Mobile Ad hoc Network

In Ad hoc network, nodes are free to move in any direction. The network does not have any central administration device such as access points or base stations. Since the nodes are mobile in nature, ad hoc network do not have any pre-defined structure [1].

In ad hoc network, all nodes are supported by battery powers with limited capacity. Therefore, **routing** is one of the key issues in MANET. Along with this, energy efficient routing is another most important design criterion for MANET. Power failure of a node in network affects the node itself, and also reduces its ability to forward packets to neighbor nodes. A mobile node utilizes its battery energy not only when it actively sends or receives packets but also when it stays idle [10].

Genetic Algorithm (GA) is used in MANET for searching and finding the shortest path (SP) from the source to destination. The Genetic Algorithm enhances its searching capacity for the shortest path in such dynamic environment. GA maintains backups of routes consume minimum power. This type of routing technique will help in reducing the reroute discovery, when failure occurs in the path. It will take less time in sending again the same packet to the destination and therefore it increases its throughput in the ad hoc network [12].

II. ROUTING PROTOCOLS IN MANET

Based on the behavior and timing policy of the routing, the routing protocols are classified into three main types. They are Proactive Routing Protocol, Reactive Routing Protocol, and Hybrid Routing Protocol.

A. Proactive Routing Protocol (Table Driven Routing Protocol)

Proactive Routing Protocols are table driven, so they are also called as "Table Driven Routing Protocol". In this protocol, each node maintains the routing table which contains the latest information of the routes of its neighbor nodes in the network [3]. Thus, when there is a need for a route to send packet from source to destination then it is available immediately in the table. It continuously evaluates the routes within the network so that when it is required to send the packet, route is already known and it is ready to use immediately [4]. So there is no time delay. In routing table, each row has a next hop for reaching each node in the network and cost of each route [6].

Examples of such protocols are Optimized Link State Routing (OLSR), Destination Sequenced Distance Vector Routing (DSDV), etc [2].

B. Reactive Routing Protocol (On Demand Routing Protocol)

Reactive Protocols are also called as "On Demand Routing Protocol". The packets that are forwarded are based on query-reply conversation. This protocol does not maintain route tables like proactive protocol. When a node wants to establish a route, it sends a route request (RREQ) packet to all of its neighbor nodes which are present in the network. Each neighbor node broadcasts this RREQ by adding its own address in the header part of the packet. When this packet is received by the destination node, then the route reply (RREP) is generated and sent back to the sender along with the address [7]. This protocol minimizes the routing overheads.
Examples of such protocol are Dynamic Source Routing (DSR), Ad hoc On Demand Vector (AODV), etc.

C. Hybrid Routing Protocol

In Hybrid Routing Protocol, combination of both Proactive and Reactive routing methods are used. It is better than the both of the routing protocols when used independently. It takes the advantages of both Proactive and Reactive Protocols [4]. Initially, routing is done with proactive routing protocol and then flooding is done through reactive protocol. Hybrid protocol is used when large numbers of nodes are present in the network [3].
Examples of such protocol are Zone Routing Protocol (ZRP), etc.
Table 1 lists the advantages and disadvantages of Proactive, Reactive and Hybrid Routing Protocols.

TABLE 1. ADVANTAGES AND DISADVANTAGES OF ROUTING PROTOCOLS.

Protocols	Advantages	Disadvantages
Proactive	Up-to-date routing information	Slow Convergence
	Quick establishment of routes	Tendency of creating loops
	Small delay	Large amount of resources are needed
	A route to every other node in the network is always available	Routing information is not fully used
Reactive	Reduction of routing load	Not always up-to-date routes
	Saving of resources	Large delay
	Loop free	Control traffic and overhead cost
Hybrid	Scalability	Arbitrary proactive scheme within zones.
	Limited search cost	Inter-zone routing latencies.
	Up-to-date routing information within zones	More resources for large size zones.

III. ENERGY EFFICIENT MANET ROUTING

This paper surveys and classifies various energy efficient routing mechanisms for MANETs [9]. They can be broadly categorized based on the performance of energy optimization. A mobile node consumes its battery energy when it actively sends or receives packets and also when it stays idle i.e. when a node is listening to the wireless medium for any possible communication requests from other nodes. Thus, energy efficient routing protocols reduces the active energy required to send and receive data packets and the energy during inactive state.
The two approaches to minimize the active communication energy are transmission power control and load distribution, and approach used to minimize energy during inactive communication energy is sleep/power-down mode.
Table 2 shows taxonomy of the energy efficient routing protocols [9]. Unlike shortest path, the energy related metrics are used to determine energy efficient routing path. These metrics are:

- energy consumed per packet
- time to network partition
- variance in node power levels
- cost/packet and
- Maximum node cost.

TABLE 2: TAXONOMY OF THE ENERGY EFFICIENT ROUTING PROTOCOLS

Approach		Protocols	Goal
Minimize Active Communication Energy	Transmission Power Control	• Flow Argumentation Routing (FAR) • Online Max-Min (OMM) • Power aware Localized Routing (PLR) • Minimum Energy Routing (MER)	Minimize the total transmission energy but avoid low energy nodes
	Load Distribution	• Retransmission energy Aware Routing (RAR) • Smallest Common Power (COMPOW)	Minimize the total transmission energy while considering retransmission overhead or bi-directionality requirement
		• Localized Energy Aware Routing (LEAR) • Conditional Max-Min Battery Capacity Routing (CMMBCR)	Distribute load to energy rich nodes
Minimize Inactivity Energy	Sleep/Power Down Mode	• SPAN • Geographic Adaptive Fidelity (GAF) • Prototype Embedded Network (PEN)	Minimize energy consumption during inactivity.

IV. GENETIC ALGORITHM IN MANET

[8] Genetic Algorithm is proposed by the John Holland in 1970's. Genetic Algorithm is used in MANET for searching the shortest path or minimized path from source and destination. Genetic Algorithm is based on the concept of biological neural network. It works on the survival of the fittest rule. Genetic Algorithm is different from other heuristic method. The most important difference is [9]:

1. A Genetic Algorithm works on population of possible solutions, while other heuristic method uses a single solution in their iterations.
2. Another difference is that genetic algorithm is randomly determined or generated and it is not

deterministic. Each individual represents a possible solution.

Figure 2 shows the four stages of the Genetic Algorithm terminology. [5] In each cycle, a new generation of the solution for a given problem is generated. In the first stage, an initial population of the possible solution is created which is the starting point for the search. Then each element of the population is encoded into the string chromosomes, which are then manipulated by the genetic operators.

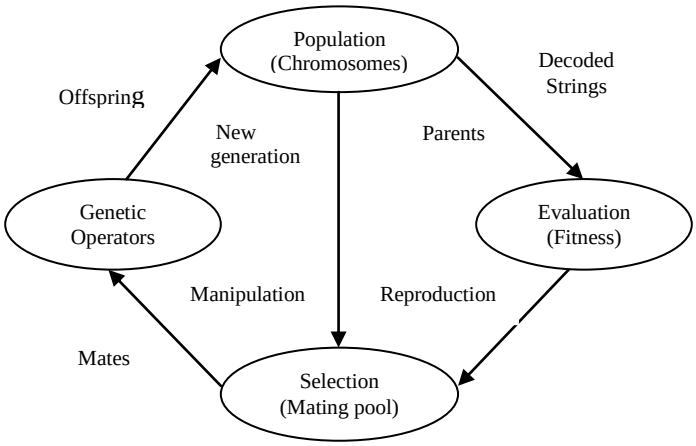

Figure 2. Genetic Algorithm Cycle

In the next stage, the fitness of each individual of the population is evaluated, with respect to the aim imposed by the problem. A selection mechanism chooses the best "characteristics" for the genetic manipulation process based on each individual's fitness. It is main factor that is responsible for satisfying the survival of the best fitted individuals.

- *Genetic Operators:*

Genetic Operators plays a very important role in Genetic Algorithm. [5] These operators are used to generate new offspring at each generation or iterations. Once an initial population is randomly generated, the algorithm uses following three operators based on natural selection.

1. *Selection*

This is the first operator applied on population. It selects the fittest individuals from the generated population. It gives priority to better individuals, allowing them to pass to the next generation.
Roulette Wheel Selection and Boltzmann Selection are the two main methods used in Selection.

2. *Crossover*

Crossover is a second genetic operator that combines two chromosomes (parents) to produce a new chromosome (offspring). The idea behind crossover is that, the new chromosome may be better than both of its parents. It takes the best characteristics from each of the parents. It is generated according to the crossover probability defined by the user. Crossover selects genes from parent chromosomes and creates a new offspring. It is the prime distinguished factor of GA from other optimization techniques.
The methods used for the crossover are One-Point crossover, Two-Point crossover, Uniform crossover, Arithmetic crossover and Heuristic crossover.

3. *Mutation*

After a crossover is performed, mutation takes place. Mutation is a last genetic operator used to maintain genetic diversity from one generation of a population of chromosomes to the next. Mutation performs random modifications. The evolution of mutation also occurs according to the user-definable mutation probability, usually set to a very low value, say 0.01. The mutation operator alters one or more gene values in a chromosome from its initial state. It results in generating entirely new gene values which is being added to the gene pool. With the new gene values, the genetic algorithm is able to arrive to a better and optimal solution than was previously possible. Mutation is an important part of the genetic search. It helps to prevent the search falling into a local optimum of the state space.
The methods used in mutation are Flip-bit, Boundary, Non-Uniform, Uniform and Gaussian.

Basic steps for a serial Genetic Algorithm:

Firstly, evaluate initial population
Select one set of parents
Apply genetic operators on parents to create new offspring.
Insert new offspring into population, replacing select individuals in population [10].

A simple genetic algorithm consists of the following steps:

1. **Initial Population**: - It generates random number of population of n chromosomes.

2. **Fitness**: - It evaluate the fitness function f(x) of each chromosome x in the generated population.

3. **New population**: - It create a new population by applying following steps until the new population is generated

   a) **Selection**: - It selects two parent chromosomes from a population according to their fitness.
   b) **Crossover**: - It performs crossover with crossover probability to form a new offspring.
   c) **Mutation**: - It mutates new offspring at given point
   d) **Accepting**: - It places the newly generated offspring in a new population.

4. **Replace**: - Replaces newly generated population for a further execution of algorithm.

5. **Test**: - If the end condition is satisfied, it stops, and returns the best solution in current population.

6. **Loop**: - Go to step 2.

Role of Genetic Algorithm in MANET

Genetic Algorithms have applications in finding optimized network topology, and it also finds a total solution to ad hoc network design [5]. Due of this topology optimization, genetic algorithm finds the failure nodes which will break the network into two or more pieces, resulting in improving reliability factor of the network.

The optimization process then constructs the links again to improve reliability of network. Such a reliability requirement finds that no two identical paths that connect every two nodes in the network exist. This gives rise to an ad hoc network, which interconnects adjacent nodes. It works on a depth-first search to test network bi-connectivity. A depth-first search visits every node and checks every link in the network systematically.

A genetic algorithm gives the probable solution of a problem as a set of parameters are encoded as a string of binary bits. Standard genetic algorithm manipulations, such as crossover and mutation, mix and recombine the genes of a parent population are used to form offspring for the next generation.

V. CONCLUSION

The emergence of MANETs has brought great development in the field of wireless networking. The mobility of the nodes has reduced the cost of infrastructure units such as access points and base stations. Several routing protocols have been designed. Each routing protocol meets specific requirements. The different categories of routing protocols presented above gives an overall idea on how the group is formed, their maintenance and also data forwarding in the network.

Due to its many advantages and different application areas, the field of MANETs is rapidly growing and changing. An efficient routing protocol is required to discover routes between mobile nodes in order to make progress in communication within a MANET. Energy efficiency is one of the main problems in MANET, especially when there is a need for designing a routing protocol.

Genetic algorithm finds the shortest path in less time. Genetic algorithm is work faster than the routing protocols.

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