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Multi - Objective Genetic Algorithm based Study for Energy Efficient Routing in MANET

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***Abstract*—** Mobile Ad hoc Networks (MANET) possess dynamic topology and have no fixed infrastructure. Numerous challenges in routing in MANETs exist because of its frequent and unpredictable topology. One of the major constraints in designing of these protocols is the battery power. Various routing protocols have been implemented for finding optimal path from source to destination considering the cost and efficient use of energy. This paper explores different types of routing protocols, their merits and demerits, approach of routing protocols and implementation of one such energy efficient routing protocol technique using Genetic Algorithm to determine the shortest path between the source and the destination. Routing protocols based on Genetic Algorithm gives us the insight that how the concepts of genetics are applied to MANETs and is used to determine an optimal route taking into account the optimization of battery power. Genetic Algorithm takes less computational time, provides multiple optimal paths in case of failure of one path as well as increases the throughput of the network. In addition it covers the significance of Genetic Algorithm in MANETs.

***Keywords*—** Mobile Ad hoc Network (MANET), Routing Protocol, Efficient Routing Protocols, Genetic Algorithm(GA)

I. INTRODUCTION

In digital era, the use of laptops, computers and mobile phones are growing rapidly due to progress in technologies and comparatively low cost. The main focus is on making the communication system wireless, robust with the optimization of energy efficiently. Mobile Ad hoc networks (MANET) are infrastructure less i.e. it comprises of independent nodes communicating with one another with the help of radio waves. The nodes in the MANET are mobile in nature. Nodes that are within a particular radio range communicate directly with each other and far away nodes communicate with the help of routing algorithms [1]. A wireless interface is used to communicate with other nodes. In MANET, every node behaves as a router as well as a host and due to this there are frequent changes in the topology of network. The purpose of this work is to implement genetic algorithm for finding an optimal path from source to destination and maximizing the throughput of the network. Here, different routing protocols have been studied and genetic algorithm is discussed for energy efficient routing. Figure 1 shows a sample network of mobile ad hoc network.

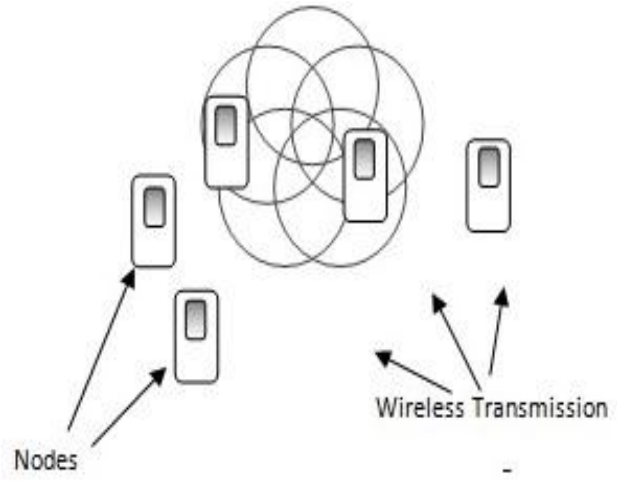

Figure 1. Mobile Ad Hoc Network

There exist two major norms in MANET that emerges routing. Firstly, the battery power with inadequate capacity in ad hoc network supports the available nodes. Secondly, energy efficient routing is a further most important design norm for MANET as power failure of a node in network affects the node itself, and also reduces its ability to forward packets to neighbour nodes.

A mobile node utilizes its battery energy not only when it actively sends or receives packets but also when it stays idle [2]. Thus, Genetic Algorithm (GA) is used in MANET for searching the shortest path (SP) from source to destination 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 [3].

This paper is organized in following sections: Section I contains introduction to MANET. In Section II classification of MANET routing protocols is discussed. Section III contains energy efficient routing. In Section IV genetic algorithm and its significance is discussed. In Section V conclusion and future scope is discussed.

II. MANET ROUTING PROTOCOL CLASSIFICATION

There exist three kinds of routing protocol classified on the basis of the behaviour and timing policy of the routing. These are proactive routing protocol, reactive routing protocol, and hybrid routing protocol described as follows:

A. Proactive Routing Protocol (Table Driven Routing Protocol)

Proactive Routing Protocols are table driven thus known 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 [4]. 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 so there is no time delay [5]. 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. Its advantages include up-to-date routing, quick establishment of routes and small delay whereas the disadvantages are slow convergence, tendency of creating loops and need of large amount of resources.

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. Its advantages are reduction of routing, saving of resources and free of loop while the disadvantages comprises large delay, controlled traffic and controlled overhead cost and not always up-to-date routes.

C. Hybrid Routing Protocol

In Hybrid Routing Protocol, combination of both proactive and reactive routing methods is used. It is better than the both of the routing protocols when used independently. It takes the advantages of both proactive and reactive protocols. 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 [8]. Examples of such protocol are Zone Routing Protocol (ZRP). The advantages of hybrid routing protocol are scalability, limited search cost and up-to-date routing information within zones. The disadvantages include arbitrary proactive scheme within zones, inter-zone routing latencies and more resources for large size zones.

III. ENERGY EFFICIENT ROUTING IN MANET

In this study performance of energy optimization based classification has been proposed for various MANET energy efficient routing mechanisms. Energy efficient routing aims at making optimal use of energy as well as maintaining the lifetime of the network as long as possible. Battery power is the major constraint in designing of these protocols as the mobile node actively sends or receives packets and even it stays idle (i.e. when a node is listening to the wireless medium for any possible communication requests from other nodes) consumes its battery energy. Nodes consume less energy when they are in sleep state. Sleep state is the duration in which nodes neither send nor receive any signals. Energy can be saved by keeping more nodes in sleep state.
Thus, an energy efficient routing protocol reduces the active energy essential to send and receive data packets and the energy during inactive state. Here, we discuss, the two approaches to minimize the active communication energy are transmission power control and load distribution. Moreover, an approach used to minimize energy during inactive communication energy is illustrated as sleep/power-down mode. Table 1 shows taxonomy of the energy efficient routing protocols. Unlike shortest path, the energy related metrics are used to determine energy efficient routing path.

These metrics are mentioned below:

- energy consumed per packet
- time for network partition

- variance in node power levels
- cost/packet and
- maximum node cost

Table 1. 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 bidirectionality 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

Genetic algorithm is proposed by the John Holland in 1970 for searching the shortest path or minimized path from source and destination in MANET. Genetic Algorithm is defined on the concept of biological neural network. It works on the principle of survival of the fittest rule. Genetic Algorithm is different from other heuristic method with following reasons:

- Genetic Algorithm works on population of possible solutions, while other heuristic method uses a single solution in their iterations.
- 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. 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.

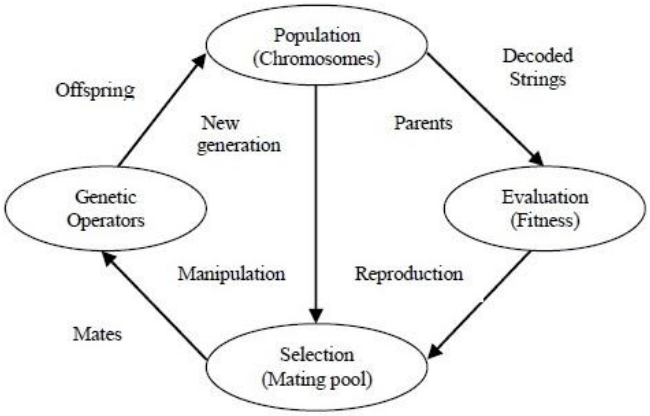

Figure 2. Genetic Algorithm Cycle

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 a significantly attributed for satisfying the survival of the best fitted individuals.

A. Genetic Operators

Genetic Operators plays a very important role in Genetic Algorithm. 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:

Selection

This operator is applied on population to select the n fittest individuals from the generated population. It prioritizes better individuals and allowing them to pass to the next generation. The two main methods frequently used in selection are Roulette Wheel Selection and Boltzmann Selection.

Crossover

Next, crossover genetic operator combines two chromosomes (parents) to produce a new chromosome (offspring). The idea behind crossover is to have 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 major notable aspect 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.

Mutation

Subsequently, mutation takes place. It is an important part of the genetic search. 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 that 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 previously possible. 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.

B. 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 [9]

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 creates a new population by applying following steps until the new population is generated.

3.1 **Selection**: - It selects two parent chromosomes from a population according to their fitness.

3.2 **Crossover**: - It performs crossover with crossover probability to form a new offspring.

3.3 **Mutation**: - It mutates new offspring at given point.

3.4 **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.

C. Significance of Genetic Algorithm in MANET

Genetic algorithms applied for finding optimized network topology, and it also locates a complete solution to ad hoc network design. Due of this topology optimization, genetic algorithm uncover the failure nodes responsible for breaking the network into two or more piece that results in improving reliability factor of the network.

Subsequently, the optimization process constructs the links to improve reliability of network yet again. Such a reliability requirement suggests 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.

Consequently, 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 AND FUTURE SCOPE

The emergence of MANETs has grappled its importance 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 provide an overall plan 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. In nutshell, genetic algorithm finds the shortest path in less time and thus works faster than the routing protocols. Further this algorithm can be studied, modified and implemented to find multiple optimal paths in case of failure of one path considering energy optimization.

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