A New Approach for Energy Efficient Routing in MANETs Using Multi Objective Genetic Algorithm

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***Abstract*— Mobile ad hoc networks (MANET) are self-creating networks. They contain short radio range and limited bandwidth and they do not have any infrastructure support. There is a sudden change in topology of ad hoc networks. In such 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. Power failure of a node affects overall lifetime of a network. In this paper, a new approach based on genetic algorithm has been proposed for energy efficient routing in mobile ad hoc network. A new crossover operator is used to generate child node from two parents. The algorithm not only provides best path to transfer data but also alternate paths to transfer data which can be used when one path fails. It increases the overall lifetime of the network and also make the network more reliable**.

Keywords: **MANETs, Routing Protocols, Energy Efficient Routing Protocols, Genetic Algorithm.**

1. INTRODUCTION

Now-a-days the use of personal communication devices like personal digital assistants (PDAs), mobile phones and mobile computers are growing rapidly due to progress in technologies and comparatively low cost. These devices get easily access to the network through wireless interfaces [1].

A mobile ad-hoc network (MANET) is a collection of independent nodes. They communicate with each other with the help of radio waves. The nodes in the MANET are mobile in nature i.e. nodes can move from one position to another. The nodes communicate directly with each other within the radio range and the nodes which are far away communicate by some routing algorithms [2]. Each node has wireless interface to communicate with other nodes. In MANET, each node acts both as a router and as a host & even the topology of network may also change rapidly. The organization of ad hoc networks is point-to-point and multi-hop. Nodes transfer information packets in a store-and-forward mode from a source to any arbitrary destination via intermediate nodes. As the nodes are mobile, any change in network topology is communicated to other nodes so that the topology information can be updated or eliminated. It is not possible for all mobile nodes to be within the range of each other [1]. However, all the nodes are close by within radio range.

The ad hoc network is infrastructure less i.e. they do not have any fix infrastructure for communication. Fig**.** 1 shows a sample network of mobile ad hoc network.

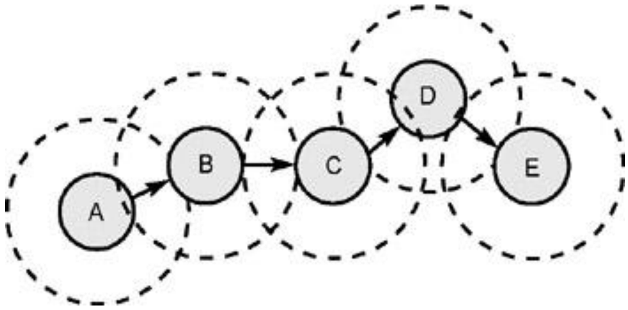

Fig 1. Mobile Ad Hoc Network

In ad hoc networks, each node forward data to other nodes in the network dynamically, based on the network connectivity. This is in contrast to the infrastructure-based networks in which designated nodes, usually with custom hardware and variously known as routers, switches, hubs, and firewalls, perform the task of forwarding the data. All nodes in this network are mobile and they use wireless connections to communicate with various networks [3].

These networks introduced a new art of network establishment and are well suited for environments where either the infrastructure is lost or where deploying an infrastructure is not cost-effective. Ad hoc network supports anytime and anywhere computing.

Routing is the process of choosing a path in a network for moving packets form source to destination. It basically involves two processes like finding an optimal routing path and transferring the packets in the internetwork [1].

Routing protocols are broadly categorized as Proactive Routing protocol, Reactive Routing Protocol and Hybrid Protocols.

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

Reactive Protocols are called also called as “On Demand Routing Protocol”. These protocols do not update the routing information periodically as there is no routing table present for keeping routing information. Each node has route cache [5]. The packets that are forwarded are based on query-reply conversation. This protocol does not maintain route tables like proactive protocol. Examples of such protocol are Dynamic Source Routing **(DSR)**, Ad hoc on Demand Vector **(AODV),** Location Aided Routing **(LAR)**, Temporally Ordered Routing Algorithm **(TORA)**, etc.

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 [6]. Initially, routing is done with proactive routing protocol and then flooding is done through reactive protocol. Examples of such protocol are Zone Routing Protocol (ZRP), etc.

II. RELATED WORK

Many research works has produced so much innovation and novel ideas in this field. Due to the limited energy resources, there has been research on improving the energy efficiency of wireless ad hoc network. Several ad hoc routing algorithms such as Dynamic Source Routing (DSR), Ad-hoc On Demand Distance Vector Routing (AODV), Temporally Ordered Routing (TORA) and Destination Sequenced Distance Vector (DSDV) have been evaluated in terms of energy consumption [7].

Anjum Asma [8] proposed an energy efficient routing algorithm for maximizing lifetime of MANETs. The author optimizes the algorithm after analyzing two metrics. The two metrics are Total transmission energy of a route and Maximum number of hops.

Sangeeta Kurundkar and Apoorva Maidamwar [9] proposed an improved AODV routing protocol for mobile ad hoc networks. They proposed a stability factor which observes and stabilize energy among the nodes and delay reduction mechanism which reduces the average end-to-end delay of the network.

Sonia Ahuja and Sukhpreet Kaur [10] proposed an energy efficient approach for routing in mobile ad hoc networks using genetic algorithm and ACO Ant colony optimization.

P. Prasanna et.el. [11] proposed an energy efficient multicast routing based on genetic algorithm for mobile ad hoc networks. The proposed algorithm works on two factors: (1) End to End delay (2) Minimum energy cost of the multicast tree.

Priti Gaur [12] suggests an implementation of multicast routing using genetic algorithm. Author proposes a new kind of path discovery strategy that promises to deal with dynamic nature of mobile ad hoc networks.

In paper [13], author proposed a new approach to minimize the energy consumption using ZRP protocol, named DPSZRP and analyzed proposed routing algorithm with various parameters and its performances for different number of nodes.

Genetic Algorithms are search and optimization techniques modeled from natural selection. The GA simulates this process through coding and its operators. The underlying principles of GAs were first published in [7].

A genetic algorithm maintains a population of the solution, where each solution is usually coded as binary string called a chromosome. The best choice of coding has been shown to be a binary in coding scheme [7]. A set of chromosomes forms a population, which is evaluated and ranked by fitness evaluation function. The fitness evaluation function plays an important role in GA because it provides information about how much good the solutions are. The initial population is usually generated by random. The evolution from one generation to the next population involves mainly three steps: fitness evaluation, selection and reproduction.

III. PROPOSED WORK

Mobile Ad Hoc networks have few problems like limited wireless transmission range, broadcast nature of the wireless medium, hidden terminal and exposed terminal problems, packet losses due to transmission errors and mobility, stimulated change of route, battery constraints and security problem. One of the most critical issues in mobile ad hoc networks (MANETs) is energy conservation since mobile nodes are powered by batteries with limited capacity. Nodes in MANET are always portable devices powered by battery. Routing is a major challenge in mobile ad hoc networks. It has been stated in the literature that most of the devices in MANETS works on batteries. The power of battery is an important resource in MANETS. The lifetime of the networks depends upon the power consumption of the nodes in the network. Routing algorithm must consume the battery power of the nodes of the MANET efficiently.

Genetic algorithms can be used in routing protocols for mobile ad hoc networks. Genetic algorithm can find an optimal path between nodes of the MANET to transfer data. It can also be used to find an energy efficient path to transfer data between two nodes. In this paper a new algorithm using GA has been proposed to find energy efficient path(s) between two nodes. The proposed algorithm also finds alternate paths which can be used when any of the one links fails in the best path.

The new algorithm tries to deal with two problems which are as follows:

1. Finding efficient route to transfer data between nodes of the MANET that consumes less power.
2. To provide alternate paths when one route get failed because of the mobility problem of mobile ad hoc networks.

Proposed Algorithm

In this paper, a new energy efficient routing protocol in MANETs using genetic algorithm has been proposed. In the literature it has been found that Genetic algorithms can be used in routing protocols for mobile ad hoc networks. Genetic algorithm can find an optimal path between nodes of the MANET to transfer data. It can also be used to find an energy efficient path to transfer data between two nodes. In this thesis work a new algorithm using GA has been proposed to find energy efficient path(s) between two nodes. The proposed algorithm also finds alternate paths which can be used when any of the one links fails in the best path. The algorithm has been applied on a network of 65 nodes.

The proposed algorithm is as follows:

1. Initialize the source and destination node. Find all the nodes in the ad hoc and their neighbors.
2. Initialize the cost matrix to find the cost to transfer packet from one node to another.
3. Initialize a sample population of 50 paths randomly.
4. Calculate the cost of each path in the population.
5. Select random parent’s paths which will participate in crossover to generate new paths.
6. Perform cross over and generate new children.

7. Calculate cost of the newly generated children.
8. Add new children (which are not in population) in the population.
9. Sort population on the cost of the paths and select next population of best 20 paths (paths with minimum path length).
10. Repeat steps 5-9 till criteria to stop does not reach.

The algorithm has been implemented in java.

The proposed procedure is as follows:
Let suppose node - 1 is the source node and node - 60 is the destination node and algorithm has to find an optimal path between these nodes. First, it finds its neighbor nodes as friends and population will be generated randomly to transfer data from node - 1 and node - 60.

Node = 1 Friends 8 7 3 4
Node = 2 Friends 4 6 7 8 9
Node = 3 Friends 8 4 5 1 7
Node = 4 Friends 6 8 9 1 3 2 5
Node = 5 Friends 8 7 6 4 3
.
.
.
Node = 60 Friends 64 59 63 55 58
Node = 61 Friends 65 57 56 62
Node = 62 Friends 64 63 61 57 58 59
Node = 63 Friends 62 64 59 60
Node = 64 Friends 62 68 67 60 63
Node = 65 Friends 67 68 61

According to these neighbor nodes, then it generates cost matrix of 65 x 65.
Now it generates 50 random paths from source to destination.

Path
- 1 - 7 - 8 - 3 - 4 - 2 - 9 - 12 - 10 - 13 - 14 - 17 - 19 - 22 - 27 - 32 - 37 - 42 - 43 - 46 - 45 - 48 - 49 - 50 - 55 – 60

Path
- 1 - 7 - 6 - 2 - 4 - 5 - 8 - 11 - 15 - 12 - 16 - 17 - 19 - 21 - 22 - 27 - 26 - 30 - 33 - 29 - 31 - 32 - 34 - 38 - 41 - 37 - 35 - 39 - 44 - 45 - 46 - 50 - 49 - 52 - 53 - 57 - 62 - 63 – 60

Path
- 1 - 4 - 5 - 8 - 2 - 6 - 7 - 12 - 14 - 11 - 15 - 19 - 22 - 27 - 29 - 28 - 31 - 33 - 32 - 35 - 37 - 41 - 46 - 48 - 44 - 39 - 36 - 34 - 38 - 40 - 42 - 45 - 47 - 49 - 52 - 53 - 58 - 60

It generates such 50 paths and now it calculates cost of each above paths from path 0 to path 49 and finds best path according to shortest path.

Path 0 = [1, 7, 8, 3, 4, 2, 9, 12, 10, 13, 14, 17, 19, 22, 27, 32, 37, 42, 43, 46, 45, 48, 49, 50, 55, 60]
Cost = 386

Path 1 = [1, 7, 6, 2, 4, 5, 8, 11, 15, 12, 16, 17, 19, 21, 22, 27, 26, 30, 33, 29, 31, 32, 34, 38, 41, 37, 35, 39, 44, 45, 46, 50, 49, 52, 53, 57, 62, 63, 60]
Cost = 627

Path 2 = [1, 4, 5, 8, 2, 6, 7, 12, 14, 11, 15, 19, 22, 27, 29, 28, 31, 33, 32, 35, 37, 41, 46, 48, 44, 39, 36, 34, 38, 40, 42, 45, 47, 49, 52, 53, 58, 60]
Cost = 656

Path 3 = [1, 8, 2, 9, 12, 7, 11, 10, 13, 14, 17, 19, 21, 23, 24, 29, 27, 26, 25, 30, 32, 37, 40, 38, 36, 34, 35, 39, 44, 48, 49, 50, 51, 53, 52, 57, 59, 60]
Cost = 612

Best Path no = 0 [1, 7, 8, 3, 4, 2, 9, 12, 10, 13, 14, 17, 19, 22, 27, 32, 37, 42, 43, 46, 45, 48, 49, 50, 55, 60]
Cost = 386

These 50 paths form the population of the genetic algorithm and find fitness function and calculate average path cost. This is the initial population of the genetic algorithm.

====== FITNESS OF THIS POPULATION ======

Best Path no = 0 [1, 7, 8, 3, 4, 2, 9, 12, 10, 13, 14, 17, 19, 22, 27, 32, 37, 42, 43, 46, 45, 48, 49, 50, 55, 60]
Cost = 386
Average Path Cost = 532.8823

Now it sorts the initial population in ascending order of cost.

Now out of 50 total populations (paths) 20 randomly paths (parents) are selected.

Randomly Generated Parents Are
2
37
33
42

Thereafter, first two parents (taken whole path) are crossed with each other using one-point crossover (say common city) and two new children are formed. Then, next two parents are considered and two new children are generated and so on. Hence, it generates 20 new children.

Parent Path1: 2: [1, 4, 3, 8, 7, 12, 11, 14, 15, 19, 22, 27, 26, 21, 23, 25, 30, 32, 34, 35, 39, 44, 45, 47, 43, 48, 51, 49, 54, 55, 60] Cost = 402

Parent Path2: 37: [1, 3, 5, 4, 8, 9, 12, 14, 17, 15, 19, 22, 21, 23, 24, 29, 30, 25, 26, 27, 31, 32, 37, 35, 34, 36, 40, 44, 39, 42, 45, 47, 43, 46, 50, 55, 60] Cost = 598
Common City = 4

Children Generated Are

Child 1 [1, 4, 8, 9, 12, 14, 17, 15, 19, 22, 21, 23, 24, 29, 30, 25, 26, 27, 31, 32, 37, 35, 34, 36, 40, 44, 39, 42, 45, 47, 43, 46, 50, 55, 60] Cost = 548

Child 2 [1, 3, 5, 4, 3, 8, 7, 12, 11, 14, 15, 19, 22, 27, 26, 21,

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23, 25, 30, 32, 34, 35, 39, 44, 45, 47, 43, 48, 51, 49, 54, 55, 60] Cost = 452

These generated children are merged in the initial population excluding with same paths that already exists in the initial population. This generates extended initial population.

Here is also calculates number of nodes in path and minimum no of nodes path is taken into consideration in order to save energy. This is the cost generated by only one iteration. This is done for n=100. Till then cost goes on decreasing and at some point it remains stable and that is the shortest path.

===== FITNESS OF THIS POPULATION =====
Best Path no = 0 [1, 6, 9, 10, 14, 17, 22, 26, 30, 33, 36, 40, 44, 49, 47, 52, 50, 52, 56, 60] Cost **= 261**

Average Path Cost = 370.43137
Very Initial Population after **Iteration 10**
Press Enter To Continue.........

===== FITNESS OF THIS POPULATION =====
Best Path no = 0 [1, 3, 9, 10, 14, 17, 22, 26, 30, 33, 36, 40, 44, 49, 47, 52, 50, 52, 56, 60] Cost **= 236**

Average Path Cost = 294.2549
Very Initial Population after **Iteration 20**
Press Enter To Continue.........

===== FITNESS OF THIS POPULATION =====
Best Path no = 0 [1, 3, 9, 10, 14, 17, 22, 26, 30, 33, 36, 40, 44, 49, 47, 52, 56, 60] **Cost = 222**

Average Path Cost = 266.70587
Very Initial Population after **Iteration 30**
Press Enter To Continue.........

===== FITNESS OF THIS POPULATION =====
Best Path no = 0 [1, 3, 9, 10, 14, 17, 22, 26, 30, 33, 36, 40, 44, 49, 47, 52, 56, 60] **Cost = 222**

Average Path Cost = 257.56863
Very Initial Population after **Iteration 40**
Press Enter To Continue.......

IV. COMPARATIVE ANALYSIS

Table 1 shows a comparative study of various routing protocols on seven different factors. It can be observed that GA based routing protocol has all the properties similar to table driven routing protocol. As in table driven routing protocol a table has to be maintained that store the information about the complete network. When a route is to be found from one node to another that table is referenced to find the route.

TABLE 1 Comparative Study of Various Routing Protocols

Sr. No.	**Protocol Property**	**DSDV**	**DSR**	**AODV**	**Proposed GA Based protocol**
1	**Table driven/ Source Routing**	Table Driven	Source Routing	Table driven and Source Routing	Table Driven
2	**Route Discovery**	Periodic	On Demand	On Demand	Periodic
3	**Network Overhead**	High	Low	Medium	High
4	**Multiple Routes**	No	Yes	No	**Yes**
5	**Reactive/ Proactive**	Proactive	Reactive	Reactive	Proactive
6	**Routing Overhead**	Medium	Low	High	Medium
7	**Network Suitable For**	Less number of nodes	Up to 200 nodes	Highly Dynamic	**Highly Dynamic**

GA based proposed routing protocol also maintain a table similar to table driven routing protocols. The main advantage is that it found many routes to send data from source to destination. So multiple route property is "yes" for GA based routing protocols. It makes the system more reliable as if there is any problem in sending the data via best route, the alternate routes provided by GA based routing protocols can be used.

Another advantage of GA based routing protocol is that complexity in finding the route does not increases rapidly with number of nodes of the network. Because GA follows evolutionary technique of finding a solution by encoding, crossover thus it is suitable for a large network. So 7th property which is network suitable for is also improved as compared to table driven protocols.

Fig. 2 shows the graphical comparison of Proposed GA based routing and traditional flooding based routing:

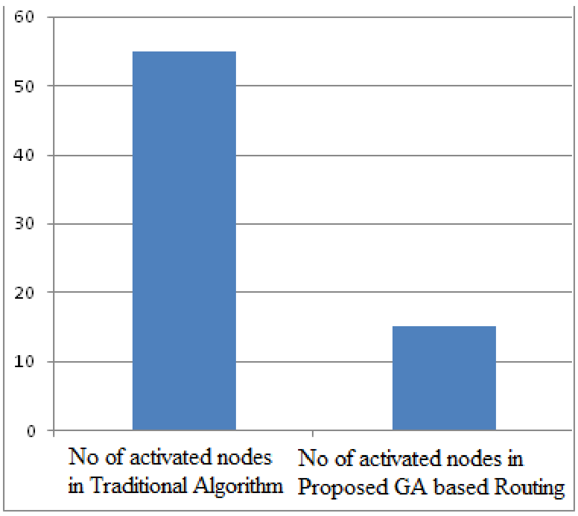

Fig 2. Graphical comparison of Proposed GA based routing and traditional flooding based routing

In flooding algorithm, (Existing Algorithms) if a node want to communicate to other node then it send the packet to all the neighbors nodes and all the neighbors also try to send the packet to their neighbors till the packet reaches to the final destination and acknowledgement is not received. This technique will activate many of the nodes in the network.

Consider sample network of 55 nodes, and then if node 1 wants to send a packet to node 55, then it activate all the 55 nodes in the network. Whereas our proposed GA the best path is

[1, 9, 14, 19, 24, 29, 33, 37, 41, 46, 44, 48, 50, 54, 55]

Cost = 215

V. CONCLUSION AND FUTURE SCOPE

In this paper, a new algorithm for energy efficient routing protocol using Genetic Algorithm has been proposed and implemented. The algorithm works on an initial population of paths to transfer data from source to destination. On this initial population different genetic operations has been applied and this initial population improves after every iteration. The proposed algorithm gives us a set of paths to transfer packet from source to destination. It can be concluded that genetic algorithms can be used to find optimal path that uses power of nodes efficiently to transfer packets in MANETS. The algorithm not only provides us optimal paths but also a list of paths which consume power slightly more than the best optimal paths. As MANETS are dynamic in nature so a link between two nodes may break at any time. In that case, the alternate paths can be used to transfer packets. So this proposed algorithm is more reliable in nature.

In future the algorithm can be implemented on a network of more than 100 nodes and its performance can be checked. The work can be further optimized by applying different parent selection techniques such as tournament selection, roulette wheel selection, ranked selection etc. Different cross over operators such as two point crossover and multipoint cross over can also be applied and results can be tested.

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