APPLICATION OF GENETIC ALGORITHM IN DESIGNING A SECURITY MODEL FOR MOBILE ADHOC NETWORK

Kumar Nikhil[1] and Swati Agarwal[2] and Pankaj Sharma[3]

[1]Department of IT, *ABES Engineering College, Ghaziabad (U.P.), India*
kumar_nikhil20@rediff.com
[2]Department of IT, *ABES Engineering College, Ghaziabad (U.P.), India*
swatiabes08@gmail.com
[3]Sr. Asstt. Professor (IT), *ABES Engineering College, Ghaziabad (U.P.), India*
sharma1.pk@gmaill.com

Abstract:

In recent years, the static shortest path (SP) problem has been well addressed using intelligent optimization techniques, e.g., artificial neural networks, genetic algorithms (GAs), particle swarm optimization, etc. However, with the advancement in wireless communications, more and more mobile wireless networks appear, e.g., mobile networks [mobile ad hoc networks (MANETs)], wireless sensor networks, etc. One of the most important characteristics in mobile wireless networks is the topology dynamics, i.e., the network topology changes over time due to energy conservation or node mobility. Therefore, the SP routing problem in MANETs turns out to be a dynamic optimization problem. GA's are able to find, if not the shortest, at least an optimal path between source and destination in mobile ad-hoc network nodes. And we obtain the alternative path or backup path to avoid reroute discovery in the case of link failure or node failure.

Index Terms:

Ad hoc Network, Genetic Algorithm, Proactive, MANET, Cluster head Gateway, Routing Optimization.

1. INTRODUCTION

A mobile *ad hoc* network *(MANET)* is an autonomous network that consists of mobile nodes that communicate with each other over wireless links. This type of networks is suited for use in situations where a fixed infrastructure is not available, not trusted, too expensive or unreliable. A few examples include: a network of notebook computers or *PDAs* in a conference or campus setting, rescue operations, and headquarters industry. In the absence of a fixed infrastructure,

Natarajan Meghanathan, et al. (Eds): ITCS, SIP, JSE-2012, CS & IT 04, pp. 181–187, 2012.

DOI : 10.5121/csit.2012.2116

nodes have to cooperate in order to provide the necessary network functionality. Routing is one of the primary functions each node has to perform in order to enable connections between nodes that are not directly within each other's send range. The development of efficient routing protocols is a non trivial and challenging task because of the specific characteristics of a MANET environment:

• Due to node movements, the network topology may change randomly and rapidly at unpredicted times.

• The available bandwidth is limited and can vary due to fading, noise, interference.

• Most mobile devices are battery powered; therefore energy consumption plays an important role.

In *ad–hoc* networks nodes geographically close to each other are grouped into non overlapping sub networks, clusters. Each cluster has a leading node called the clusterhead and a number of cluster members. When a cluster member wants to communicate with another node, a route is provided by its clusterhead. A crucial question is which node will become a clusterhead. Typically a clusterhead is more burdened than its members and could easily become a bottleneck of the system if not chosen appropriately.

Hence solutions to this problem are based on heuristics approaches. A good clustering scheme should preserve its structure as much as possible, when nodes are moving and/or the topology is slowly changing. Otherwise, recompilation of cluster heads and frequent information exchange among the participating nodes will result in high computation overhead. Any node can become a clusterhead if it has the necessary functionality, such as processing and transmission power. Nodes register with the nearest clusterhead and become members of that cluster. Clusters may change dynamically, reflecting the mobility of the underlying network.

The rest of the paper is organized as follows: section 2 deals with routing in ad hoc networks. Section 3 introduces the genetic algorithm as an optimization technique. Section 4 includes the steps that are required to apply the Genetic algorithm. Section 5 contains routing optimization using genetic algorithm. Conclusions are summarized in section 6.

2. ROUTING IN AD-HOC NETWORKS

2.1) Proactive/Reactive Ad Hoc Routing Protocols

The existing *ad hoc* routing protocols can be broadly classified into the following two categories:

Proactive protocols (e.g. WRP or wireless routing protocol): by broadcasting control packets containing routing table information (e.g. distance vector), these protocols attempt to maintain at all time up-to-date routing information from each node to every node.

Reactive protocols *(e.g.* AODV or Ad hoc on-demand distance vector routing): only when a route to destination is required, a node initiates a route discovery process. Once a route has been established, it is maintained by a route maintenance procedure until the route is no longer desired. *Unfortunately*, these protocols suffer from a number of shortcomings: scalability problems with growing network size and their performance is only optimal under certain network conditions (mobility, network load, network topology).

2.1.1) Clusterhead Gateway Switch Routing Protocol

Clusterhead gateway switch routing protocol *(CGSR)* in Figure 1 is based on dynamic destination sequenced distance vector (*DSDV*) which belongs to proactive routing protocols . *CGSR* uses a Least Cluster Chance (*LCC*) algorithm in which a clusterhead chance occurs only when two cluster heads come into one cluster or one of the nodes moves out of the range of all cluster heads. In this algorithm, each node maintains two tables, namely, a cluster member table which records the clusterhead for each destination node and routing table which contains the next hop to the destination. The cluster member table is broadcasted periodically. A node will update its cluster member table when it receives a new one from its neighbors using sequence numbers. To route a packet to a destination, the node first selects the shortest (minimal hop) clusterhead corresponding to the destination from the cluster member table and routing table and then transmits the packet to the next hop according to the routing table entry corresponding to that cluster heads, thus, the routing principle looks as follows: lookup of the clusterhead of the destination node, then lookup of the next hop, packet send to destination, at last destination clusterhead deliver packet.

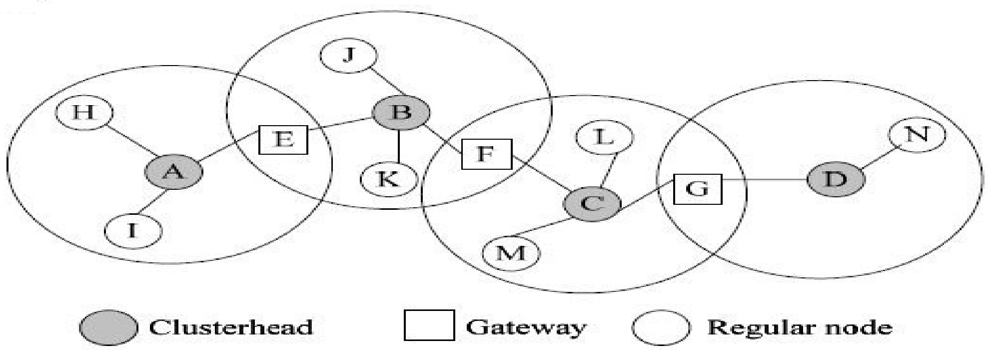

Figure 1: Illustration of single level clustering hierarchy used in CGSR

This approach has numerous disadvantages*: **first**,* selection of cluster heads causes complexity and overhead, thus degrading performance. ***Second***, there are traffic bottleneck and single point failures at the cluster heads and gateways. ***Finally***, *CGSR* is hierarchical routing protocol that uses *DSDV* as its underlying routing algorithm but reduces the size of routing update packets in large networks by partitioning the whole network into multiple.

3. GENETIC ALGORITHMS

The GA**,** which was introduced by John Holland, was adopted from natural evolution. Natural evolution has the following features:

1) The characteristics of an individual are encoded on a chromosome.
2) Each chromosome has certain fitness according to the environment in which it exists.
3) Individuals judged stronger are able to survive and produce next generations of strong individuals.

The GA is based on the above features in the following manner: the solution of the problem is encoded on a string comparable with the chromosome of the biological system.

The GA keeps a population of randomly selected chromosomes and allows filter chromosomes to combine and produce offspring with new characteristics, which may replace low fitness old chromosomes. This is repeated until we find a chromosome with best characteristics, which represents the optimal solution of the problem.

There are two mechanisms that link a genetic algorithm to the problem it is solving. These two mechanisms are:
1) Encoding solutions to the problem on chromosomes.

2) Evaluation function that returns a measurement of the worth of a chromosome in the context of the problem.

This is what we call the fitness of a chromosome. The evaluation function plays the same role in the genetic algorithm that the environment plays in natural evolution.
In order to use GA's for network topological design, the chromosome is chosen to contain the network parameters. A possible chromosome would be a string containing the weights of all nodes of the network. The evaluation function which assigns fitness to each chromosome is chosen according to the objective of the design problem. If the objective is to minimize the route between source and destination, then the evaluation function will compute the all distances of all possible paths between source and destination and give the dynamic optimal path with time change.

4. BASIC STEPS OF A SERIAL GENETIC ALGORITHM:

Evaluate population- AHP modeling
Select one set of parents,
Apply genetic operators to parents to create new offspring.
Insert new offspring into population, replacing select individuals in population.[3]
A simple genetic algorithm consists of the following steps[4]:

1. [Initial Population] Generate random population of *n* chromosomes (suitable solutions for the problem)
2. [Fitness] Evaluate the fitness *f(x)* of each chromosome *x* in the population
3. [New population] Create a new population by repeating following steps until the new population is complete

a) [Selection] Select two parent chromosomes from a population according to their fitness (the better fitness, the bigger chance to be selected)
b) [Crossover] With a crossover probability cross over the parents to form a new offspring (children). If no crossover was performed, offspring is an exact copy of parents.
c) [Mutation] With a mutation probability mutate new offspring at each locus (position in chromosome)
d) [Accepting] Place new offspring in a new population

4. [Replace] Use new generated population for a further run of algorithm

5. [Test] If the end condition is satisfied, stop, and return the best solution in current population
6. [Loop] Go to step 2

5. ROUTING OPTIMIZATION USING GENETIC ALGORITHM

The goal consists of allocate near optimal path from source to destination based on time, giving priority to cluster heads to maximize utilization and minimum delay.[5]

Step1: Encoding and Initial Population

All nodes in the search space should be present and have a unique representation. If there is a one-to-one correspondence between the search space and string representation, the design of the genetic operator would be considerably less complex. These unique id's are used to encode the chromosome using integer permutation Encoding the individual chromosomes is an essential part of the mapping process; each chromosome contains information about the clusterheads and the members thereof, as obtained from the original clustering algorithm.

Each chromosome is represented by a link weight vector $W = < w1....w(n)>$ where *(n)* is the total number of links in the network. The value of each weight is within the range from *1* to *MAX_WEIGHT*. We define the value of *MAX_WEIGHT* to be *64* for reducing the search space. The population size is set to 100, with the initial values inside each chromosome randomly varying from *1* to *MAX_WEIGHT*.

Step2: Fitness Evaluation

Chromosomes are selected according to their fitness. The bandwidth constraint is embedded into the fitness function as a penalty factor, such that the search space is explored with potential feasible solution. The fitness of each chromosome can be defined to be a two-dimensional function as shown in Equation 1. The overall network load *(L1)* and excessive bandwidth allocated to overloaded links
(L2).

$$\text{Fitness} = f(A1,A2) = c/(a \times L1 + b \times L2) \qquad (1)$$

Where *a* , *b* and c are manually configured coefficients.
A1 and *A2* are expressed as shown in equations 2, 3, 4.

$$A1=\sum_{g=1}^{G} D_g \qquad (2)$$

$$A2=\sum_{(I,j)\in\sum} W_{ij} \times (\sum_{g=1}^{G} D_g - C_{ij}) \qquad (3)$$

Where

$$W_{ij}=\{0 \text{ if } \sum^{G} D_g <= C_{ij}) \text{ or } \{1 \text{ otherwise} \qquad (4)$$

Where:
Dg: Bandwidth demand for *cluster g* on each link;
Cij: Bandwidth capacity of link *(i,j);*

G: total number of active clusters.

So the objective function is two fields: first chromosomes of the new generations. And second, solutions obtained from the offspring should be feasible in that the total bandwidth allocated flows traveling through each link should not exceed its capacity. The tuning of $\acute{\alpha}$ and β can be regarded as a tradeoff between overall bandwidth conservation and load balancing. For example we let $\beta = 0$ then the objective is to conserve bandwidth resources only, while setting $\acute{\alpha} = 0$ infers to minimize link overloading within the network.

Step3: Crossover and Mutation

According to the basic principle of Genetic algorithms**,** chromosomes with better fitness value have higher probability of being inherited into the next generation. To achieve this, first we rank all the chromosomes in descending order to their fitness, so the chromosomes with high fitness (lower overall load) are placed on the top of the ranking list. Then we partition this list into two disjointed sets, with the top 50 chromosomes belonging to the upper class (*UC*) and the bottom 50 chromosomes to the lower class (*LC*). During the crossover procedure, we select one parent chromosome C_u^i from UC and other parent C_l^i from *LC* in generation "*i*" for creating the child C^{i+1} in generation *i+1*. We use a crossover probability threshold K_c ε *(0.05)* to decide the genes of which parent to be inherited into the child chromosome in the next generation. We introduce a mutation probability threshold K_M to randomly replace some old genes with new ones.

6. CONCLUSIONS

We presented a genetic algorithm as an optimization technique for routing in *MANET*. The results show that, with the genetic algorithmic technique each clusterhead handles the maximum possible number of mobile nodes in its cluster in order to facilitate the optimal operation of the medium access control (*MAC*) protocol, reduce the number of clusters and hence cluster heads, as well as, the loads among clusters are more evenly balanced by factor of ten.

A genetic algorithm technique mapped the possible solutions given by a weight based distributed clustering algorithm in order to find the better solution from a pool of solutions. Each clusterhead handles the maximum possible number of nodes in its cluster. Also a fewer cluster heads are obtained by the genetic algorithm technique. With the genetic algorithm technique the cumulative distributions of the paths are almost the same. Generally, another criterion of research can concentrate to simplify parameters of GA's optimization to leave the bad one out and optimize the good parameters. The genetic algorithm can also be implemented to other criteria of research such as robotic systems for the purpose of achieving the best performance.

7. REFERENCES

[1] Abolhasan, M., Wysocki, T., & Dutkiewicz, E. (2004). "*A Review of Routing Protocols for Mobile Ad hoc Networks.*", VOL 2, ISSUE 1, 1-22.

[2] S.Narayanaswamy, V.Kawadia, R.S. Sreenivas, and P. R.Kumar "*Ad-Hoc Networks: Theory, Architecture, Algorithm and implementation of the Compow protocols* " Proc. of European wireless (2002). Next generation wireless networks: Technologies, Protocols, Service and Applications, PP. 156-162, Floence, Italy.

[3] Er.Rakesh Kumar1,Dr Piush Verma2,Dr.Yaduvir Singh,"*Design and Development of an Intelligent Routing Protocol for Mobile Ad hoc Network :A Review Paper in IJCSNS International Journal of Computer Science and Network Security*", VOL.10 No.9, September 2010.

[4] P. Sateesh Kumar, S. Ramachandram," *Genetic Zone Routing Protocol*",proc. Journal of Theoretical and Applied Information Technology.

[5] *Mustafa AL-GHAZAL, Ayman EL-SAYED (IEEE Member), Hamedy KELASH," Routing Optimization using Genetic Algorithm in Ad Hoc Networks*",proc. ISSPIT 2007, 15-18 December 2007, Cairo, Egypt.

[6] G. Pei et al.," *wireless Hierararchical Routing Protocol with Group Mobility*," proc. IEEE WCNC'99, New Orleans,LA, Sept.(1999).

[7] C.E. Perkins and E.M.Rayer, "*Ad-Hoc On Demand Distance Vector Routing,*" Proc. (IEEE) WMCSA '99 New Orleans,LA,Feb. (1999),pp.90-100.

[8] Clarles E. Per Kins and Pravin Bhagwat "Highly *Dynamic Destination Sequenced Distance Vector Routing (DSDV) for mobile computer* "SIGCOMM, ACM (1994).

[9] Ching-Chuan Chiang and Hasiao Kuang Wu and Winston Liu and Mario Gerla" *Routing in Clustered Multihop, Mobile Wireless Networks with fading Channel*" IEEE Singapore Internationl Conference on networks, SICON'97, April (1997).

[10] Dalma Turgut, Sajal K.Das. " *Optimizing Clustering algorithm in Mobile Ad hoc Networks* ", Journal of Clustering Computing, Vol. 5, No. 2. Oct. 2002. pp.193-204.

[11] Kumar Nikhil, Swati Agarwal "A review of routing protocols for mobile adhoc networks", ICNICT, Dec. 2011

AUTHORS:

Kumar Nikhil, is a final year student IT engineering. Earlier he has done his Diploma in Mechanical engg from Aligarh Muslim University, Aligarh. His areas of interest includes Computer Networks, Software Testing.

Swati Agarwal, topper of her department, is a student of the final year IT engineering and has also published a research paper in a national conference earlier on Neuro Linguistic Programming. Her areas of interest include DBMS, Software Testing and Computer Networks.