Improving DSR Protocol Using Genetic Algorithms in ad hoc Mobile Networks

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Abstract—Ad hoc mobile networks are a special kind of computer networks that have no pre-defined infrastructure. In this kind of networks, nodes can freely move in any direction. Due to mobility of nodes, routing in this kind of networks has always been problematic. Most existing protocols use simple algorithms and criteria for routing; while there are other important criteria for path selection. To remove these deficiencies, the existing protocols should be optimized using some algorithms. In this paper, the proposed method is consisted of three phases of path discovery, path selection and repair and maintenance. After path discovery in the source node, the obtained path will be optimized using genetic algorithm and used for sending the data packages. The results of simulation showed that throughput, rate of package delivery and the assumed energy have improved compared to two other protocols. However, in terms of mean of end-to-end delay, DSR acts better than proposed model. The reason is the time spent for processing for selection of optimum path.

Keywords— Genetic algorithm, optimization, routing protocol, ad hoc network, DSR.

I. Introduction

Ad hoc network includes a set of distributed nodes that without any infrastructure or central management constitute temporal network [1]. In this kind of networks, no there is no infrastructure similar to router or access point, rather, the nodes could act both as router and host. Any node in the ad hoc network is free to independently move in any direction; thus, its links to other nodes frequently change. Due to mobility of nodes, the network topology is dynamic and variable. Thus, in so far as nodes could continuously change their location, the network needs a routing protocol with the capability of compatibility with these changes [2].

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In the second part of this paper, the related works in demand-based routing protocols are presented. In third part, optimization algorithm to be used in proposed protocol will be explained. The fourth part presents the proposed method for optimization of routing in ad hoc networks. Then, in the fifth part, the assessment and practical results will be presented and finally it will be concluded..

II. Related Literature

Several years ago, about 60 proposals of routing protocols were studied. Nowadays, just a few numbers of these proposals are used as protocol [4]. DSR protocol is a source and demand-based protocol, a node keeps a mass of paths including those paths and routes from the source that it is informed of [5]. The data entered in the data storage will be updated when new information about the current paths is obtained. Two main phases of this protocol include path discovery and repair and maintenance of path. In TORA protocol, its main feature is centralization of the control messages in a very small collection of nodes close to the location where topology changes have happened [6]. To achieve this, the nodes keep routing information in intervals of neighboring nodes. Protocol has three main tasks of path creation, path repair and path deletion. ARAMA protocol is a biology-based routing algorithm [7]. In designing this algorithm, ant colony has been taken as idea. The forwarding packages are used for network data collection and returning packages for updating the routing information in nodes. The benefits of this algorithm include appropriate response to changes, attempt for local problem solving, utilization of the features of both active and demand-based routings, the high number of presented paths, reliable connections and the ability to control updates [8]. In Ant-AODV protocol, the nodes depend on ant for obtaining information. The features of this protocol include decreased end-to-end delay and delay in path discovery. Moreover, despite the active protocols, they do not waste the bandwidth with control overhead [9]. Bee Ad hoc protocol has inspired from the honey bee laws for finding food and utilizes three agents, i.e. packing agents, scout agents and food finders. This protocol includes three phases of path discovery, path response and repair and maintenance

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that compared to other algorithms have similar or better efficiency; however, in terms of energy, it has much less consumption. To achieve this objective, it sends less control packages just the same as the behavior that the bees in nature show [10].

III. Optimization Algorithms

There are many methods and algorithms for optimization. For using an optimum appropriate method for a problem, first all aspects of the problems should be studied and analyzed. Then, fully understanding the subject, it is possible to begin selecting an appropriate optimization method. By studying various routing algorithms and obtaining the advantages and disadvantages of them, it is approximately possible to guess that optimization of routing will be possible. Although, new deficiencies might be added to previous ones and some of the previous deficiencies might be probably deleted.

A. Genetic Algorithm

Genetic algorithm is a method for optimization with wide search and its application is based on principles of normal selection governing natural genetics. The idea of this algorithm has been taken from Darwin evolution theory. In this algorithm, historical information about evolution is efficiently extracted and used in searching. Genetic algorithm is a powerful method and acts well on a wide range of issues [11].

At the beginning of algorithm, some people are randomly selected as initial population and a quality criterion, called target function or fitness, is assessed for them. If the condition for reaching answer is not established, the next generation will be produced by selection of parents based on their fitness rate. In each generation, the best members will be selected and after reproduction, a new collection of children will be produced. The chromosomes in population are selected as parent based on their fitness. Then, reproduction happens between pair chromosomes to produce children and the children will be mutated with a constant probability. Then, the fitness of new children will calculated and new generation will be produced by replacement of parents with children and the produced generation will be known as next generation and this continues. In this process, more appropriate people will remain in next generation with higher probability and this process continues until the ending condition is established [12].

IV. Proposed Protocol

To improve path selection and common efficiency parameters in the network, here, a demand-based routing protocol is proposed for ad hoc networks. During path discovery, this protocol finds several paths from source to destination the same as other demand-based algorithms. Then, it stores one initial path and one supporting path from the achieved paths so than in case of link break, it could be used and in this way, iteration of path discovery process will be avoided. To improve paths and find optimum paths from various accessible paths saved in the path table, genetic algorithm will be used. The proposed protocol includes three phases.

- Path discovery
- Path selection
- Path repair and maintenance

A. Path Discovery Phase

Path discovery phase includes two parts of sending route request package (RREQ) and route reply package (RREP). The process of path discovery starts by broadcasting of RREQ. According to table (1), RREQ includes source and destination node addresses and a unique identification number. Any middle node checks whether there is any path to destination node or not; if there is no path, it adds its own address in this package and sent it for his neighbors. In order to limit the number of publishing RREQ, a node just processes the package if it has seen it just once; i.e. its own address in not in the routing record of that package.

TABLE I:
ROUTE REQUEST FORMAT

SA	DA	Seq#	TTL	Hops	Partial Path

- SA: This field includes address of source node
- DA: This field includes address of destination node
- Seq#: The unique number that is produced by the source for unique identification of package.
- TTL: This field is produced to limit lifelong of package and at the beginning, it has zero value.
- Hop: This field indicates the number of steps. The value of this field increases 1 by 1 for any node through which the package passes. At the beginning, this field is zero as default.
- Path field: This field contains the path that the package has passes so far. When the package passes a node, its address is added to the end of this field.

In destination node, up to a specified time interval, RREQ packages arrived from different paths are collected and by changing the status to RREP packages, they are send to source node from the same path that RREQ packages have come by adding accessible bandwidth of any BWi node and remaining energy Eni of any node in the path. The format of RREP package in proposed method is according to table (2).

TABLE II
ROUTE REPLY FORMAT

SA	DA	Seq#	Hops	En_i	BW_i	Partial Path

A RREP is produced when the destination node or a middle node receive RREQ with the existing knowledge on the destination node. The RREQ router record includes a sequence of routers passing source node to current node.

B. Path Selection Phase

After finding a path from source node to destination node, these paths will be included in route table shown in table (3) in a specified time interval. Using route table and selecting a path for optimization, path selection phase starts that will be explained in following.

Any row of table is a path from source to destination and a reply to problem in genetic algorithm. Any row of table is considered as a chromosome and all paths in the route table are considered as initial population. In our proposed method, accessible bandwidth to any node and the remaining energy of any node are considered as criteria for obtaining fitness function.

TABLE III
ROUTE REQUEST FORMAT

Source									Dest
1	2	8	15	3	4	6	3	14	10
1	3	5	6	18				9	10
1	12	7	3	5	2	6	8		10
1	3	8	2	4	6	3	14	9	10
1	5	2	4		8			3	10
...	...								...

We will obtain fitness function of any path using equation (1) concerning the considered criteria.

$$fitness_K = \sum_{i=1}^{N} \left(Bw_i^k + EN_i^k\right) \Big/ _N \quad (1)$$

Where, Bw_i^k is bandwidth of ith element of chromosome k and its unit is Bps and EN_i^k is remaining energy of ith element of chromosome k and its unit is Jules and N is the number of middle nodes between source and destination. One path will be selected from route table and entered to genetic algorithm as input; then, its fitness will be calculated. In the next section, for optimization of path on path chromosome, a conscious mutation and crossover will be performed; i.e. instead of mutating a random node as a gen, using the node information in neighbor's table, a node will be selected that is neighbor of neighbors of selected node for mutation. The procedure of proposed method is as figure (1).

```
Old_Path=One_Path in Route Table
Best=Fitness (Old_Path)
For n=  to # of iterations
Generate a small smart stochastic  New_Path of
the solution by GA
If Fitness (New_Path) > Fitness (Old_Path)
Old_Path := New_Path
End If
If Fitness (New_Path) > Best
Best_Path := New_Path
Best= Fitness (New_Path)
End If
End For
If Fitness (Old_Path)< Fitness (Best_Path)
Old_Path := Best_Path
Return  Old_Path
```

Fig. 1: Basic algorithm of proposed method.

C. Path Maintenance Phase

In this algorithm in route table of source node, just two paths are kept for each destination. First, the first path is used, when this path confronted with a broken link, a RREQ will be sent to source node and the source node deletes any raw that uses broken ling from its route table. Then, the source uses second path for sending information.

V. EVALUATION OF EFFICIENCY AND PRACTICAL RESULTS

In this part, the efficiency function of the proposed method will be evaluated and the results of simulation tests will be compared with DSR and Bee Adhoc protocols. We used simulator Ns 2.34 for evaluation and the results obtained from simulation have been analyzed using MATLAB2012. For evaluation of proposed method, we have defined a scenario. In this scenario, the performance of proposed method will be studied in terms of moving behavior of nodes. In this scenario, the performance of proposed method has been evaluated with variable speed of 1-20 m.s-1 through parameters in table (4).

row	Parameter	Value
1	Simulation time	**800 s**
2	Simulation area	**1000 x 1000 m^2**
3	Number of nodes	**80**
4	Transmission range	**250m**
5	Channel capacity	**2 Mbps**
6	Node Speed	**between 1-20 m/s**
7	Movement model	**Random Waypoint**
9	Pause time	**40 s**
8	CBR flows	**10 packet/s**
10	Data payload	**512 bits**
11	Initial Energy	**1 jouls**
12	Mac model	**IEEE 802.11**
13	radio propagation model	**TwoRayGround**
15	Trafic model	**UDP-CBR**
16	Routing Protocol	**Porposed-DSR-Bee**

In mobile ad hoc networks, high mobility of nodes leads to decreased rate of package delivery. This issue will be clarified concerning figure (2). This reduction is due to increased topological dynamism and consequently the link breakage in links. Due to the use of accessible bandwidth criterion for nodes, the proposed method could deliver more packages to destination; thus, this protocol yields better results than two previous protocols.

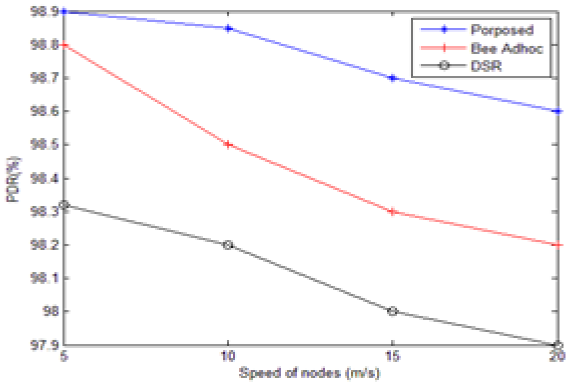

Fig. 2: Comparison of network Packet Delivery Ratio

The obtain results according to figure (3) show that increased mobility of nodes has not considerable effect in delay mean. The reason is that the probability of finding a node in neighborhood to a node will be more; thus, the establishment of a path between source and destination becomes rapid and this decreases the delay in delivery of the package to destination; however, the proposed method has more delay compared to two other protocols. The reason is that after path discovery in this protocol, a processing will happen in source node for optimization of path and this leads to increased delay.

Concerning figure (4), it is observed that increased speed of nodes' movement decreases the throughput. The slope of throughput graph of proposed method is more than DSR and Bee adhoc protocols and is more stable than topology change. The reason for this is the use of nods with high accessible bandwidth where data transfer rate is high. Thus, the throughput of proposed method is more than two other protocols. The results of three protocols in figure (5) show that increased movement of nodes increases energy consumption in network. The reason for this is instability of topology and link break in network. In case of link break, more controlling packages will be transferred for the purpose of reporting error and finding the path and this leads to higher use of energy of the nodes. In the proposed method, due to the use of optimum algorithms for selection of a path, the probability of link break will decrease; even, in case of link break, there is an optimized secondary path in the path that will immediately replace the main path. Thus, the number of controlling packages in this protocol is less and consequently, the energy consumption of this protocol is less than two other protocols.

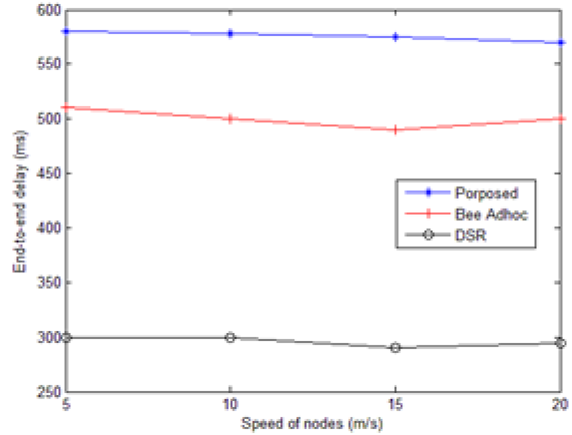

Fig. 3: Comparison of network Delay

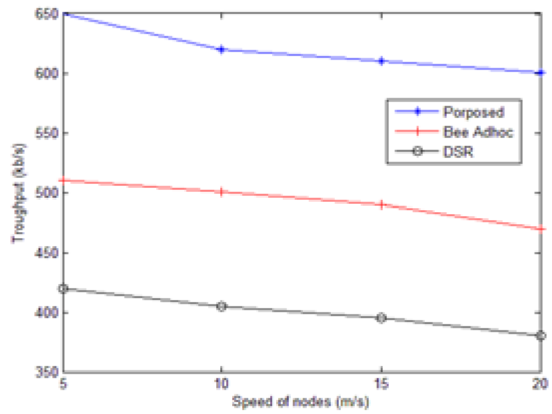

Fig. 4: Comparison of network Throughput

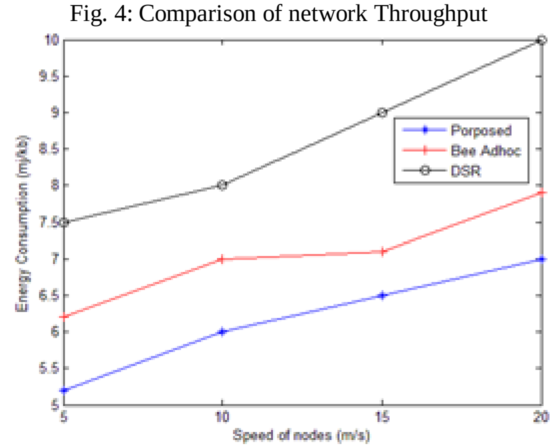

Fig. 5: Comparison of network Energy Consumption

VI. Conclusion

In this paper, a new routing algorithm using genetic algorithm was presented. Due to local optimization properties, this algorithm has good performance for optimization of routing. For this reason, the obtained path could be well optimized. Selection of optimum path based on several criteria caused the load of network to be distributed systematically. The use of paths with highest energy mean and accessible bandwidth made network sources become less in this protocol compared to other protocols; moreover, efficiency criteria increased. The only criterion that becomes worse in this study compared to other protocols was delay mean that was due to being time-consuming of processing in source node for selection of optimum path.

In so far as the proposed method keeps two paths in source, at the path break, it is possible to restart data sending with negligible cost. The results of simulation tests in this study showed that the throughput and delivery rate of packages in this protocol is more compared to other methods.

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