AN APPROACH TO DSR ROUTING QOS BY FUZZY-GENETIC ALGORITHMS

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ABSTRACT

Although, all prior works improved routing on MANETs, there is no strong advancement on QoS. One of the newest challenges to improve quality of routing in MANETs is combining the Genetic and Fuzzy algorithms into routing protocols. The improvements on routing QoS are approached by using Genetic and Fuzzy algorithms in this project. In cause of storing route information during route discovery, the DSR routing protocol is chosen by this project. First of all, the suggested protocol in this project added Current Time into DSR header. So, next intermediate node can obtain its previous link's cost by this attachment and adds the Link Cost to route discovery packet. Then, when the route discovery packet received to destination node, it will expect for other packets till end of packet TTL. Next, the destination node will use collected packets in Genetic Algorithm to find the two optimum routes. Finally, the destination node sends these routes to source node. Next improvement is using Fuzzy Triangle Numbers to change route update. In this case, the suggested protocol uses route error packets' count and also Triangle Numbers to change route update period time.

KEYWORDS

MANET, DSR, Genetic, Fuzzy, QoS

1. INTRODUCTION

Routing inMANET as a mobile self-configuring infrastructure-less wireless network is more complicated than other usual networks. A node in MANET can be both terminal node and router. Indeed, a node as a terminal node sends and receives packets while that node as a router will find and save a path, andalso conducts packets to a destination. In the other hand, topology in this kind of network is not stable because of nodes' mobility. Thus, router based routing mechanisms which try to save network topology do not work properly in MANET.

Dynamic Source Routing (DSR) as a standard routing protocol in MANET has a simple and efficient routing algorithm. DSR finds a path by sending a Route Request packet and save the hop IPs during route request flooding. There is no doubt that DSR does not consider on QoS and the first found path will be used as packets route.

Quality of Service in routing needs to ensure that chosen path has less traffic, less packet loss, optimum length, and the most possible bandwidth together. Approaching to routing QoS is impossible without consideration of nature and dynamic topology in MANET. This project has tried to use Genetic and Fuzzy algorithms in DSR to approach to QoS in MANET routing. The first part of this article will explain the used genetic algorithm. Section two will introduce our

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changes on DSR and how our protocol works. Section three is the explanation of route updating by Fuzzy. And finally, we simulate our routing protocol by NS2 and compare it with standard DSR.

2. GENETIC ALGORTHM

Researchers have used Gas in the SP routing solution, ATM bandwidth allocation solution, multicast routing solution, Capacity and Flow Assignment (CFA) solution, and the dynamic routing solution. It is clear that all these solutions can be formulated as some sort of syntactic optimization solution.

The graph G=(N,A) can specifies the underlying topology of any multi-hop network, where N is a set of nodes and A is a set of their links. Also, we can have a cost for each link (i, j) and call it as Cij. In this case, we have a source node which we named it as node "S" and a destination node with name "D". The name Iij is denoted for each link (i, j) and can be defined as follows:

$$I_{i,j} = \begin{cases} 1 \; If\ the\ link\ from\ node\ i\ to\ node\ j \\ \quad exists\ in\ the\ routing\ path \\ 0 \quad otherwise \end{cases}$$

It is clear that diametrical elements of Iij must be '0'. By using the above definition, we can formulate the SP routing solutions to syntactic optimization solution to minimize the objective function as follows:

Minimize: $\sum_{i=S}^{D} \sum_{\substack{j=S \\ J \neq i}}^{D} C_{ij} I_{ij}$

Subject to: $\sum_{\substack{j=S \\ j \neq i}}^{D} I_{ij} - \sum_{\substack{j=S \\ j \neq i}}^{D} I_{ji} = \begin{cases} 1 & if\ i = S \\ -1 & if\ i = D \\ 0 & otherwise \end{cases}$

And $\sum_{\substack{j=S \\ j \neq i}}^{D} \begin{cases} \leq 1 & if\ i \neq D \\ = 0 & if\ i = D \end{cases}$

2.1 COST

Cost for each link is formulated by RTS/CTS (Request To Send/ Clear To Send). In this way, we estimates the cost for each link (i, j) by using packet delay during a fixed packet sending.

$$C_{ij} = E_{(b_{(s,r)}^{rts})} = \sum_{i=0}^{\min(T_m,(T_s+T_{r+1}))} \sum_{j=0}^{\min(T_s,i-1)} \sum_{k=0}^{\min(T_r,i-1)} (\min(T_s - j, T_r - k) * P_{(i,j,k)}$$

In the above formula, the number of sent packet is mentioned by Tm. Ts and Tr are the activate time of node S or sender and node R or receiver. Also, we can calculate P by below formula:

2.2 FITNESS

The fitness function shows the evaluation of each chromosome based on its links' cost. Indeed, the fitness function must accurately measure the quality of chromosomes in the population. The fitness function can be formulated as follow:

2.3 CROSSOVER

Crossover checks the current solutions in order to find better ones. Physically, the role of exchanging one part of two chosen chromosomes to make better routes plays by crossover. In such a manner that the GA produces new chromosomes from previous generation by exchanging part of them, one part of route connects the source node to an intermediate node, and the other part connects the intermediate node to the destination node. Following algorithm shows the crossover process in this genetic algorithm:

```
/*    ,      : Input Chromosomes ,        ,      : Output Chromosomes */
/*     : Length of Chromosome      ,      : Length of Chromosome      */

For (all i, j) { /* Find the potential crossing sites */

                        If (    [i] ==     [j] ) { /* if a node is commonly included in both chromosomes */
                                                    [k]= (i, j); } /*Construct a set of potential crossing
sites*/
}
   = choose_rand(    ); /* randomly choose a crossing site */
   =    [1:        ] //    [        +1 :    ] ; /* 1st exchange */
   =    [1:        ] //    [        +1 :    ] ; /* 2nd exchange */
```

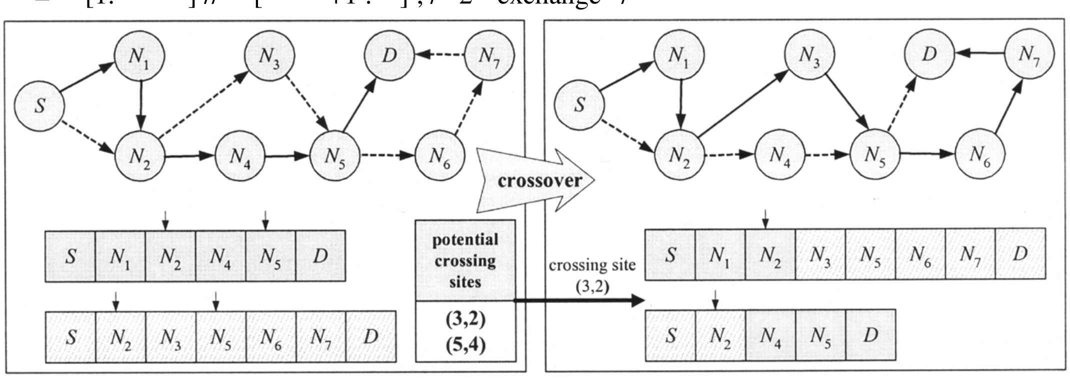

Figure1. Overall procedure of the crossover. (a) Pseudo code of the crossover. (b) Example of the crossover procedure.

2.4 MUTATION

Mutation is a process to change genes of the candidate chromosomes to improve the fitness in new generation and keeping away from local optima. Physically, it generates an alternative partial-route from mutation node to the destination node in the GA.

```
/* C: Input Chromosome,    : Output Chromosome, T: Topological Information Database */

    = Choose_rand (C); /* Randomly choose a node as a mutation point */
Delete (T, C,     ); /* Delete the nodes of upper partial-route from T */
    = C [1:     ]; /* Put the upper partial-route to the mutation chromosome */

While (1) {
            [    + 1] = Choose_rand_delete (T,     [    ]); /* Randomly choose a node from T and
        delete the node from T */
        If (    [    + 1] == destination) {
                        Break; }
            ++; /* increment the       */ }
```

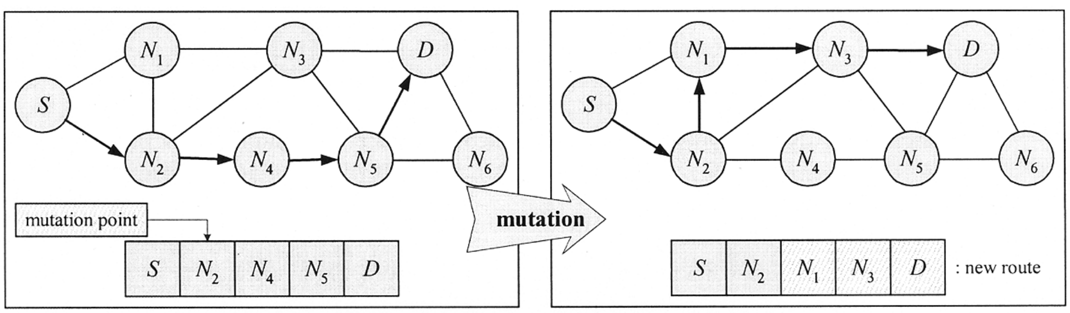

Figure 2. Overall procedure of the mutation. (a) Pseudo code of the mutation. (b) Example of the mutation procedure.

3. GA-DSR ROUTING

GA-DSR is a DSR optimized routing protocol for Mobile Ad hoc Networks which uses Genetic and Fuzzy algorithms to improve Quality of Service. This optimized protocol sends and Route Request packet to find destination, same as standard DSR, when the source node does not know route to the destination node. The difference is that this optimized protocol saves each link's cost beside the IP addresses.

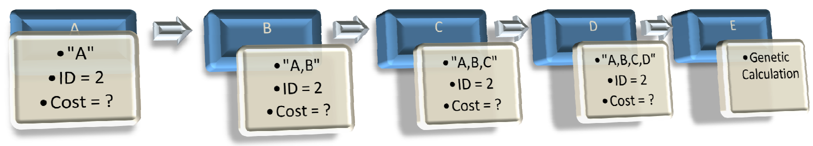

Figure 3. GA DSR Schema

When the destination node receives a RREQ packet, it saves received RREQ in its cache until the end of Route Request TTL. During this time, the destination node will save all other RREQs from same source node with same Route Request ID.

Table 1. Route Request Packet Details

Option Type	Opt Data Len		Identification
Target Address			
Current Time		TTL	
Address [1]			
Cost [1]			
Address [2]			
Cost [2]			
…			
Address [n]			

When the Route Request TTL has been finished, the destination node adds all received RREQs in Genetic Algorithm and finds the two best routes from source node to destination node. Finally, the destination node creates a Route Reply packet, adds these two routes in it and sends the RREP packet for the source node.

Table 2. Route Reply Packet Details

	Option Type	Opt Data Len	[L]	Reserved
First Route Count		Second Route Count		
Address [1]				
Address [2]				
….				
Address [n]				

The following flowchart shows the route discovery in GA-DSR:

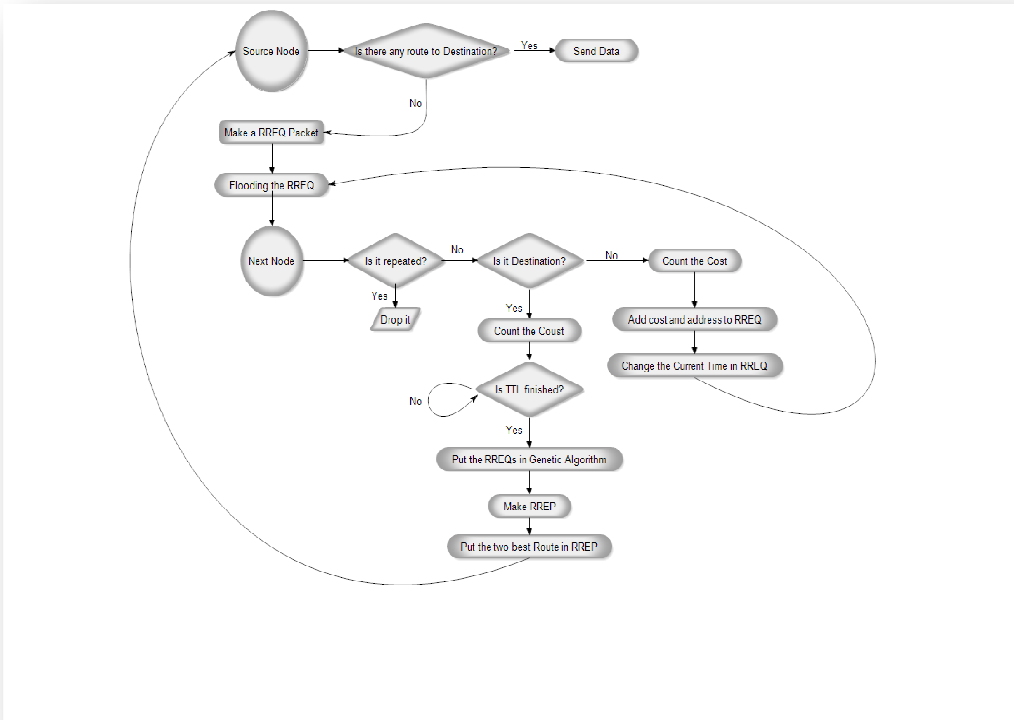

Figure 4. GA DSR Flowchart

Source node

If (Route to destination Exist)

Send (data packet);

Else {

Make (Route Request);

Flood (Route Request);

}

Receive (Next_Node)

{

If (it's destination)

{

Count (Cost);

If (TTL is not finished)

Wait();

Else {

```
                Genetic_Algorithm(Route Request[]);
                Make(Route Reply);
                putInRouteReply(Two Best Routes);
                Send(Route Reply);
            }
}
Else {
    If (Packet is repeated)
        Drop(Packet);
    Else {
        Count (Cost);
        AddToRouteRequest (Address);
        Change(Current Time);
        Flood(Route Request);


}       }
```

4. ROUTE UPDATING

Route updating can help the protocol to reduce packet loss and improve QoS. Indeed, MANETs have a mobile nature; so topology changes in them frequently. This mobile nature effects on the routes and make them unusable after a while. So, all MANET routing protocols need a route updating algorithm.

In this protocol, we use Triangular Fuzzy Numbers to make the route updating time dependent. In this case, we forecast a time for route updating and make this time error dependent based on Triangular Numbers. If the route error came from a direct node in a route, other nodes will update that route immediately. Otherwise, nodes which received route error will increase their route error counter and operate triangular equation. The result of Triangular equation should multiply to forecast time and subtract from it.

$$tri_{(x;m,a,b)} = \begin{cases} 0 & x \leq a \\ \dfrac{x-a}{m-a} & x \in (a,m], a \neq m \\ \dfrac{b-x}{b-m} & x \in (m,b], m \neq b \\ 1 & x \geq b \end{cases}$$

5. SIMULATION RESULTS

We simulated the GA-DSR protocol by NS2 for 5, 10, 15, 20, 25, 30, 35, and 40 nodes. Whereas every simulation results may have some exceptions, we simulated the GA-DSR in some times and made our decision based on their average.

5.1 ROUTE REQUESTDELAY

Whereas the GA-DSR destination nodes wait till end of Route Request TTL, there is no doubt that the result of route request delay will be more than standard DSR. By the way, the simulation shows that this difference decrease by nodes population increment.

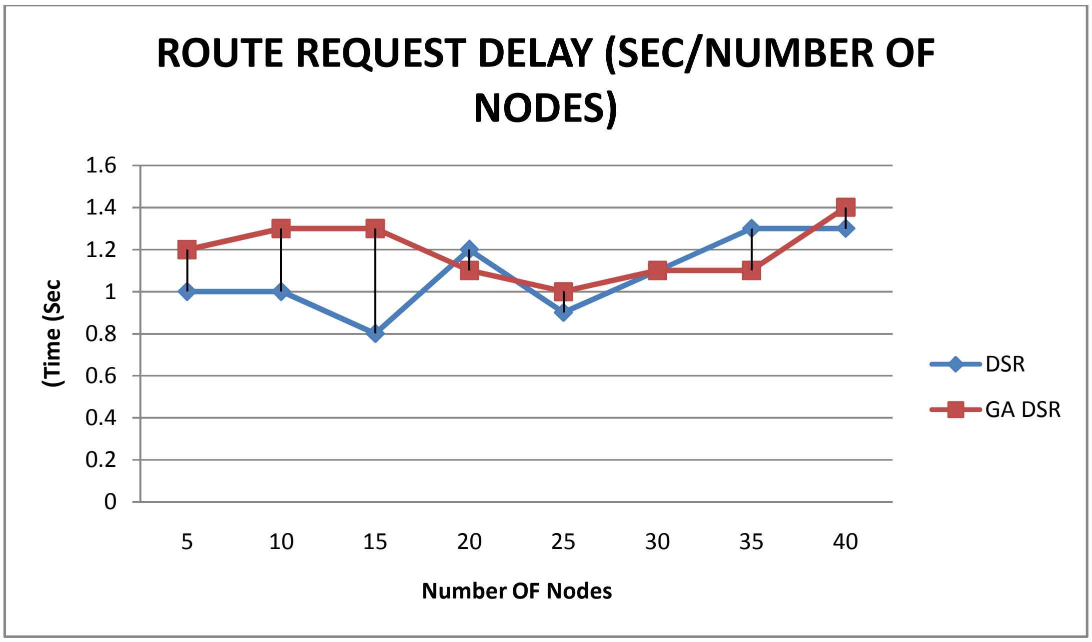

Figure 5. Route Request Delay

5.2 END TO END DELAY

End to End Delay is the most important result to prove the success of each routing protocol. The results of simulation show that the GA-DSR works more proper than standard DSR. We can see that the End to End Delay in GA-DSR is less than Standard DSR. Also, GA-DSR has more success during node population increment.

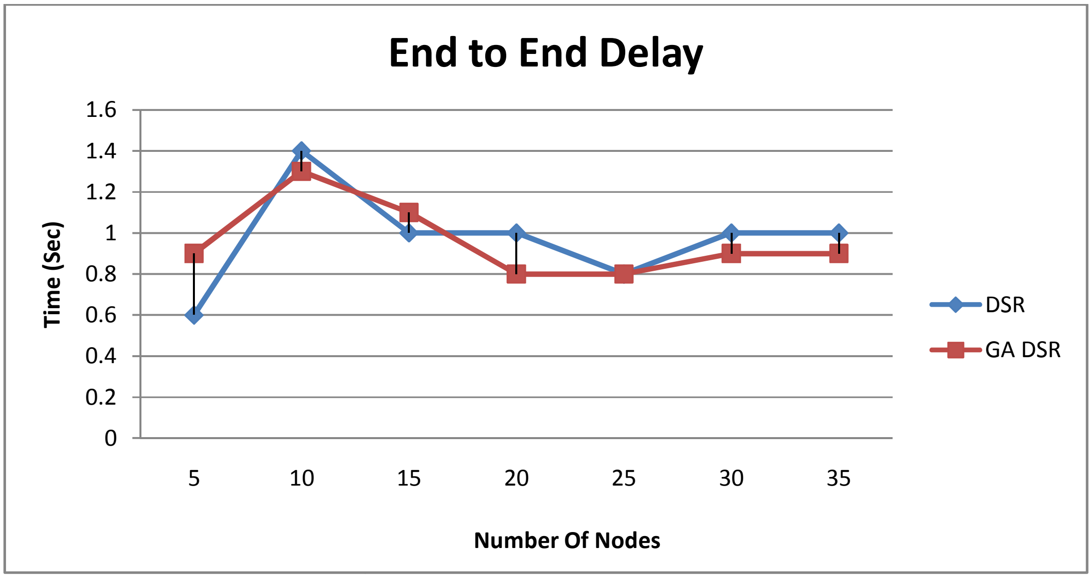

Figure 6. End to End Delay

5.3 PACKET DELIVERY RATE

Packet Delivery Rate is our final comparison between GA-DSR and Standard DSR. There is no doubt that the results of simulation show that the packet delivery rate increased in GA-DSR compare on Standard ones.

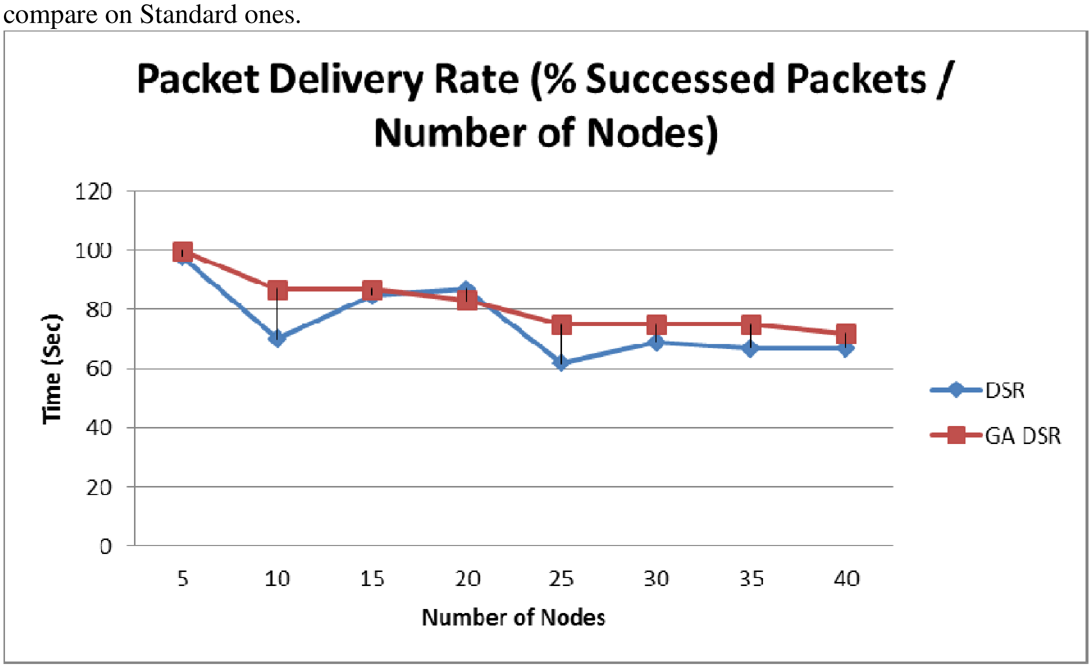

Figure 7. Packet Delivery Rate

6. CONCLUSION

This project tried to improve Standard DSR by using Genetic and Fuzzy algorithms. We proposed a GA-DSR protocol which adds link cost to route request and uses genetic algorithm in destination node to find the two best route for communication. The destination node will add these two routes in route reply and sends it for the source node.

The route updating in proposed GA-DSR protocol works by Fuzzy Triangular Numbers. It uses a route error counter and changes the route updating time based on the Triangular equation result. Finally, we simulated our proposed routing protocol and made a comparison on standard DSR in Route Request Delay, End to End Delay, and Packet Delivery Rate. The results showed us that GA-DSR improved End to End Delay and Packet Delivery rate in comparison on Standard DSR.

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