ISSN (Online): 1694-0814
www.IJCSI.org

A Fuzzy Based Stable Routing Algorithm for MANET

Arash Dana[1] **Mohamad Hadi Babaei[2]**

[1] Dept. of Elect. Eng. Islamic Azad University, Central Tehran Branch
[2] Scientific Association of Electrical & Electronic Engineering Islamic Azad University Central Tehran Branch

Abstract

The increasing popularity of using multimedia and real time applications in different potential commercial in MANETs, make it logical step to support Quality of Service (QoS) over wireless network. QoS support is tightly related to resource allocation and reservation to satisfy the application requirements; the requirements include bandwidth, delay, delay-jitter and packet to loss ratio. One of the notoriously difficult problems in QoS routing in Mobile Ad-hoc Networks (MANET) is to ensure that the established path for a connection does not break before the end of the data transmission. In order to reduce the number of broken routes, a novel reliable routing algorithm using fuzzy applicability is proposed to increase the reliability during the routing selection. In the proposed algorithm source chooses a stable path for nodes mobility by considering nodes position/ velocity information. Also we propose novel method for rout maintenance, in this protocol before breaking packet transmitted path a new one is established. The simulation results show that the algorithm can reduce the number of broken routes efficiently and can improve route stability and network performance effectively.

Keywords: *mobile ad hoc network, QoS routing, fuzzy applicability, rout maintenance*

1. Introduction

In the past decade we have witnessed a phenomenal growth in the deployment of portable wireless devices and related services, including wireless multimedia. MANET, an archetypical infrastructure-less wireless packet network, enables these wireless devices to communicate with each other without the help of base stations or other pre-existing infrastructure. While a mobile node can communicate directly with the nodes lying within its transmission range, communication with the mobile nodes outside of the transmission range must necessarily be multi-hop and require the establishment of communication paths. It is well known that most of the multimedia applications require the establishment of communication paths that satisfy a number of negotiated parameters (such as delay or bandwidth), usually referred to QoS guarantees. Due to the dynamic nature of the network topology and imprecise network state information, a lot of problems remain before more efficient solutions are found for QoS routing in MANET. One of the problems is that the established path for a connection request may break before the end of data transmission. An active path fails due to mobility when a pair of nodes forming a hop along the path move out of each other's transmits range. As general an alternative path is sought only after the current path fails. The cost of detecting a failure is high: several retries have to time-out before a path is "pronounced dead". Thus, when a path fails, packets experience large delays before the failure is detected and a new path is established. In order to confirm the stability of the whole route from source node to destination node, every link between each neighboring node should be ensured firstly. How to predict the situation of node movement in the future using current information becomes the key of predicting route stability.

Several ad-hoc routing protocols for MANETs have been proposed in recent years. Most of these routing protocols, such as Destination Sequenced Distance Vector, Optimized Link State Routing Protocol, Ad-hoc On-demand Distance Vector Routing (AODV), and Dynamic Source Routing (DSR), are belong to shortest-path routing protocols [1]. These protocols are generally based on shortest path algorithms (or minimum hop count) to determine the route paths, which may be not so robust especially for time-varying-radio-link cases. This may result in lowered throughput and increased packet loss rate. Several researchers have proposed adaptive ad hoc routing protocols; such as Associativity Based Routing (ABR) [2] and Signal Stability-based Adaptive routing (SSA) [3], to improve the Stability of discovered routes in MANETs. The goal of this paper is to select a stable path for reducing the number of broken path. To achieve this goal, source

estimate route stability coefficient (RSC) with fuzzy logic and it use RSC to select route with the highest stability for the requiring source, destination pair .Selecting the route is source responsibility for two reasons:
1-more flexibility in switch to a more stable path
2-reducing of network traffic and time for initiation route recovery
We investigate introducing preemptive route maintenance to Ad hoc routing protocols. More specifically, when two nodes are moving out of each other's transmit range, intermediate nodes of active paths warned destination a path break is likely. With this early warning, the destination can initiate route discovery and source switch to a more stable path potentially avoiding the path break altogether.
The proposed scheme utilizes GPS location information [4], and in the protocol, GPS position, velocity information is piggybacked on data packets during a live connection and is used to estimate the stability of the link between two adjacent nodes.
The rest of the paper is organized as follows. Section 2 gives a detailed description of the Route Stability Coefficient (RSC). The proposed routing algorithm is given in Section 3. The Route Maintenance algorithm and discusses some possible optimizations to it, is given in Section 4. In section 5, we do some simulations and present a comparative performance of DSR with our algorithm without Route Maintenance and with Route Maintenance. The conclusions are remarked in Section 6.

2. Route Stability Coefficient (RSC)

2.1 Description of node

In a mobile ad hoc network, the communication between two adjacent nodes needs the relative movement information of nodes. Generally speaking, the state of a node includes the position, the movement speed and the movement direction. The following are the attribute description of one node. Node: N_i (p, v)
Where i denotes the No. of one node,
p denotes the position of Node i . According to GPS location information, each node has one unique position.
v denotes the velocity of node i . It is a vector includes value and direction.

Figure 1

$\Delta d_{i,j} = P_i - P_j$

Where $\Delta d_{i,j}$ denotes the distance between node *i* and node *j*

$\Delta v_{i,j} = (v_i \cos\alpha - v_j \cos\beta) - (v_i \sin\alpha - v_j \sin\beta)$

$\Delta v_{i,j}$ means that if the velocity vectors of two nodes are similar in size and direction, the value of $\Delta v_{i,j}$ is equal zero. α denotes the angle between v_i and the line connected from node i to node j, β denotes the angle between v_j and the extended line connected from node i to node j. This part means that if the direction of v_i and v_j are face to face, the value of $\Delta v_{i,j}$ is positive , contrarily, if they are in opposite direction, the value $\Delta v_{i,j}$ is negative.

2.2 Link Stability Coefficient (LSC)

Fuzzy logic implements human experiences and preferences via membership functions and fuzzy rules. The fuzzy logic proposed to calculates the Link Stability Coefficient (LSC) of each link between source and destination. The fuzzy logic uses two input variables and one output variable. The two input variables to be fuzzified are Δd and Δv of the neighbor nodes. The inputs are fuzzified, implicated, aggregated and defuzzified to get the crisp value of LSC as the output. The linguistic variables associated with the input variables are Low (L), medium (M) and high (H) for Δd and negative (N), zero (Z) and positive (P) for Δv. For the output variable, link stability index, six linguistic variables are used. They are, very low (VL), low (L), medium (M), average (A), high (H) and, very high (VH). All membership functions are chosen to be triangular. The table 1 shows the fuzzy conditional rules for the fuzzy stability. The first rule can be interpreted as, "If (Δd is low) and (Δv is negative) then link stability is medium". Similarly the other rules have been developed.

Table 1

Δd \ Δv	N	Z	P
L	M	VH	A
M	L	H	A
H	VL	A	H

2.3 Rout Stability Coefficient (RSC)

The LSC between each neighboring nodes can be computed using fuzzy logic. Here, we use $LSC_{i,j}$ denote the LSC between node i and node j. Assume one communication route between source and destination is made up of n intermitted nodes

$RSC_{s,d} = LSC_{s,1} * LSC_{1,2} * LSC_{2,3} * \ldots * LSC_{n,d}$

$RSC_{s,d}$ denotes the Rout Stability Coefficient of the whole route.

3. Rout discovery

This process executes the path-finding algorithm to discover the stable route between source and distention. The source node initiates a route discovery process by broadcasting a Route Request (RREQ) message to all of its neighboring nodes. The RREQ packet here is similar to the RREQ in DSR protocol. Intermediate nodes receive RREQs and rebroadcast them. The destination node receives multiple RREQs within a time window, which starts from the first arrival RREQ .In this time window destination send Route Reply (RREP) per each received RREQ without delay. It creates RREP messages formatted similarly in DSR protocol for responding with the RREQs but includes a two newly field named node position and node velocity. Intermediate nodes add own position and velocity to RREP. Then the nodes forward the RREP toward the source node along the reverse route through which the selected RREQ passed. RREP packet, which contains the complete route topology information from source to destination, is sent back to the source node. The source node calculate RSC while receiving first RREP and start to transmit data packet from discovered path, by receiving next RREPs compares their RSCs with transmitted packet route RSC, in this comparing if source find route with higher RSC it will switch transmit packet path to stable path .In figure – node A is as source and G is as destination .node A broadcast RREQ to find existing routes. Node G when received $RREQ_1$ sends $RREP_1$ without delay. In table 2 shown apparent routes between source and destination, and also time difference between receiving RREQs and $RREQ_1$.

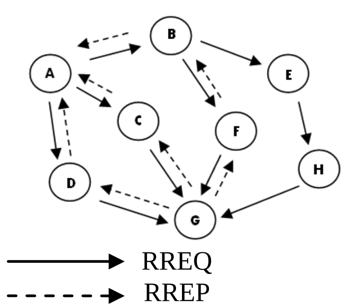

Figure 2

Table 2

RREQ Number	Discovery path	Receive time
RREQ1	A,D,G	t_1
RREQ2	A,C,G	$t_2 - t_1 < T$
RREQ3	A,B,F,G	$t_3 - t_1 < T$
RREQ4	A,B,E,H,G	$t_4 - t_1 > T$

It should be considered the received time of $RREQ_4$ (t_4) is out of time window (T), so Destination sends three RREPs to source. Source calculates RSC's after receiving RREPs. It is shown RSCs in table 3 .Source starts to transmit data packet from route 1 after receiving $RREP_1$ and will switch to route 3 by receiving $RREP_3$.

Table 3

RREP Number	RSC
RREP1	0.65
RREP2	0.54
RREP3	0.72

4. Route Maintenance

A link failure is costly because multiple retransmissions and timeouts are required to detect the failure and a new path has to be found (in on-demand routing) we propose route maintenance extension to our routing protocols. With route maintenance, recovery is initiated early by detecting that a link is likely to break and finding and using an alternative path before the cost of a link failure is incurred. Route Maintenance algorithm consists of three components: (i) detecting that a path is likely to be disconnected soon; and (ii) finding a better path (iii) switching to it. A critical component of the proposed scheme is determining when path stability is no longer acceptable. The degree of route stability is a function of neighbor nodes distance and relative velocity of neighbor nodes. If distance of two intermediate nodes (i,j) in data transmitted packet route is higher than breaking route threshold and also nodes movement be in opposite direction ($\Delta v_{i,j} < 0$) intermediate node generates breaking route warning (BRW) and sends it to destination. Destination broadcasts route recovery (RREC) when received BRW. Intermediated nodes add their position and velocity information to RREC and broadcast it .source by receive RRECs compare RSC of discovery path (and compare with RSC of transmitted packet route) if path with higher RSC exist change transmit packet path.

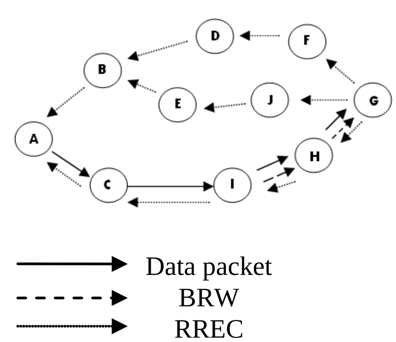

Figure 3

Generate RREC by destination and selected route by source is cause reducing initiate route recovery time. If transmitted data packet have higher RSC across exciting route between source and destination and if intermediate node generate BRW, route recovery process is start and no changing occur in transmitted data packet route, repeat this process and broadcasts RREC by destination can decrease network performance and have obverse affect. To prevent this, destination start a timer after broadcast RREC or RREP and distention drops RRECs until timer overflow.
Using preemptive route maintenance the cost of detecting a broken path (the retransmit and timeout time) is eliminated if another path is found successfully before the path breaks. In addition, the cost for discovering an alternate path is reduced (or eliminated) since the path discovery is initiated before the current path was actually broken. This can be expected to reduce the latency and jitter.

5. Performance Evaluation:

5.1 Simulation Environment and Methodology:

In order to verify the correctness of our approach and to see the performance in real application scenario, we establish a pure Ad Hoc network with 50 nodes distributed over 900mx900m area in the simulation platform during 500 seconds . A random waypoint mobility model was used: each node randomly selects a position, and moves toward that location with a speed ranging from just above 0 m/s to 10 m/s. When the node reaches that position, it becomes stationary for a programmable pause time; then it selects another position and repeats the process. We performed the simulation with various pause times 0,100,200,300,400 and 500. A mobile node is assumed to be stationary with pause time of 500 seconds. A node moves constantly with 0 second pause time. Each node has a radio propagation range of 150 meters and channel capacity is 2 Mb/s. The source-destination pairs are spread randomly over the network. Continuous Bit Rate (CBR) traffic sources were chosen, as the aim was to test the routing protocols. The sending rate used was 4 packets per second with a packet size of 512 bytes.

5.2 Performance Metrics:

The following metrics are used in computing the Performance. The metrics were derived from one suggested by the MANET working group for routing protocol evaluation.
A. Packet delivery ratio:
Packet delivery ratio is the ratio between the number of packets originated by the "application layer" CBR sources and the number of packets received by the CBR sink at the final destination.
B. Route Stability:
Route stability is a very important performance parameter for a routing protocol. Route stability can be measured in terms of number of route failures.
C: Throughput:
It is the amount of digital data transmitted per unit time from the source to the destination. It is usually measured in bits per sec.

5.3 Simulation Results:

We present below the performance of the proposed stabled Routing Algorithm (SRA) without Route Maintenance and with Route Maintenance in comparison with DSR .
Figure 4 shows the affections of different routing algorithms on route stability. Because the dynamic of network decreases as the pause time increases, the route stability of three algorithms increases.DSR shows the worst path stability.
X-axis represents the nodes paused time and Y-axis represents the numbers of broken routes. Through changing the paused time, we can see that the broken number of SRA with Route Maintenance decreases greatly compare to DSR.
Figure 5 and 6 shows the affections of different routing algorithms on network performance. As shown in Figure 5, the packet delivery ratios of three algorithms increase as the pause time increases. SRA with Route Maintenance is the best, SRA is lower than SRA with Route Maintenance, and DSR is the worst. The reason is that the stronger route stability is, the higher packet delivery ratio is. Figure 6 shows improvement in throughput over DSR against pause time.

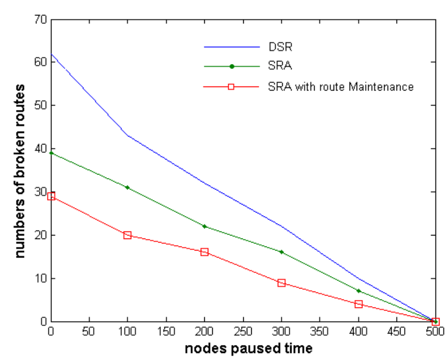

Figure 4

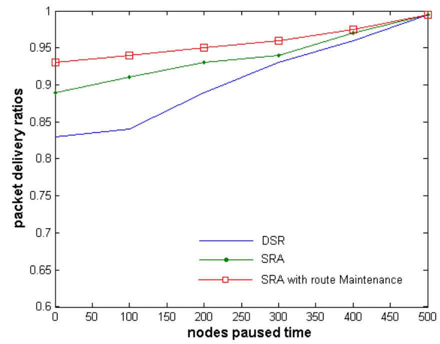

Figure 5

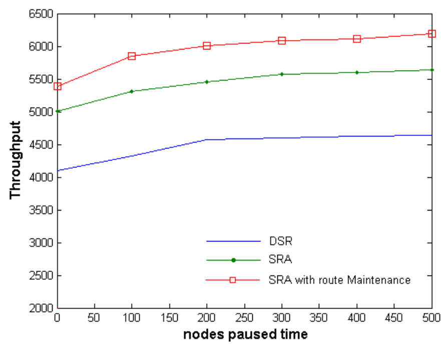

Figure 6

6. Conclusions and future work:

Mobile ad hoc networks are full of uncertainties because of dynamic topologies, dynamic traffic and different application contexts. As a well recognized decision making technique, Fuzzy logic offers a natural way of representing and reasoning the problems with uncertainty and imprecision. Fuzzy logic is a suitable way to be applied in the mobile ad hoc network routing decision. Innovation in the paper is source select rout by using important parameter. Simulation results show that the SRA with Route Maintenance algorithm improved the performance and stability of MANET networks dramatically. We believe that the proposed protocol can be further investigated based on other practical radio propagation models in order to design better adaptive mechanism for mobile ad hoc networks.

References:

[1] C.E. Perkins, "Ad hoc networking," Addison-Wesley, 2001.
[2] C.K. Toh, "Associativity-based routing for ad hoc mobile networks," Wireless Personal Communications, vol. 4 no. 2, pp. 103-139, 1997.
[3] R. Dube, C.D. Rais, K.Y. Wang, and S.K. Tripathi, "Signal stability based adaptivc routing (SSA) for ad hoc mobile networks," IEEE Personal Communications, vol. 4, no. 1, pp. 36-45, 1997.
[4] E.D. Kaplan (Editor), “Understanding the GPS: Principles and Applications”, Artech House, Boston, MA, 1996
[5] Jenn-Hwan Tamg, Bing-Wen Chuang, and Fang-Jing Wu” A Radio-Link Stability-based Routing Protocol for Mobile Ad Hoc Networks” 2006 IEEE International Conference on Systems, Man, and Cybernetics October 8-11, 2006, Taipei, Taiwan
[6]Mehdi Zarei,Karim Faez,Javad Moosavi Nya and Morteza Abbaszadeh Meinagh”Route Stability estimation in Mobile Ad Hoc Networks using Learning Automata”.16th Telecommunications forum TELFOR Serbia,Belgrade, November 25-27 ,2008