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Fuzzy Logic Based Stable Routing in VANET

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ABSTRACT

Vehicular ad hoc networks (VANETs) enable vehicles to communicate with each other (V2V) as well as roadside infrastructure units (V2I) without any fixed infrastructure. These roadside units provide different services such as driver information systems and Internet access. VANETS can be used to improve the comfort applications such as traffic information, weather information, gas station/restaurant location information or interactive communication such as Internet access and downloads. The high speed and high mobility of vehicles cause many challenges to establishing and maintaining connection of these roadside units. In this paper we introduce Fuzzy Logic Based Stable Routing in VANET. The essential purpose of new algorithm is to predict the future behaviour of vehicles by the use of the characteristics of vehicle movements such as speed average, speed of drivers and standard deviation; and also to calculate stablitiy of routes with the help of fuzzy logic for selecting routes with the most stability and least length. The proposed algorithm is simulated by considering mobility model, generated by the VanetMobiSim tool. The simulation results show that the proposed approach with increasing the number of nodes, will increase the Average Route Stability Indicator Minimum and decrease Average Route Length Minimum. This issue cause to provide an accurate and efficient method of estimating and evaluating the route stability in dynamic VANETs.

1. Introduction

Vehicular Ad hoc Networks (VANET) is the subclass of Mobile Ad Hoc Networks (MANETs). VANET is one of the influencing areas for the improvement of Intelligent Transportation System (ITS) in order to provide safety and comfort to the road users. VANET assists vehicle drivers to communicate and to coordinate among themselves in order to avoid any critical situation through Vehicle to Vehicle communication e.g. road side accidents, traffic jams, speed control, free passage of emergency vehicles and unseen obstacles etc. Besides safety applications VANET also provide comfort applications to the road users such as weather information, mobile e-commerce, Internet access and other multimedia applications [8]. Fig. 1 shows the overall working structure of VANET.

Figure 1. Vehicular Ad Hoc Network overview

VANET is a self-organizing network that does not rely on any fixed network infrastructure. However, some fixed nodes act as the roadside units to facilitate the vehicular networks for serving geographical data or a gateway to internet etc [1]. Higher node mobility, speed and rapid pattern movement are the main characteristics of VANET. These characteristics also cause rapid changes in network topology [2].

VANET is a special type of MANET, in which vehicles act as nodes. Unlike MANET, vehicles move on predefined roads. Vehicles' velocity depends on the speed signs as well as traffic signs and traffic signals [8]. There are many challenges in VANET that need to be solved in order to provide reliable services. Stable & reliable routing in VANET is one of the major issues. Also, vehicles have high speed and mobility that cause routing even more challenges. Hence more research is needed to make VANET more applicable.

First in this paper with studying variety of papers [6,7,10] kind of ad hoc routing method are considered and we identify which ad hoc routing approach has better performance in VANET. Then we create new algorithm with providing this routing method. So one of the purpose is to study different routing methods of ad hoc networks applicable in VANET, to find protocols that are more suitable in various scenarios, and to find problems with traditional MANET routing protocols that can be used in VANET. On the basis of comparison performance, we will be able to suggest which routing protocol is suitable for VANET.

Also, several researchers have proposed adaptive ad hoc routing protocols such as Associativity Based Routing (ABR) [3] and Signal Stability-based Adaptive routing (SSA) [4], to improve the stability of discovered routes in MANETs.

Hence, main aim of this paper is to select a stable path for reducing the number of broken paths in VANETs. To achieve this aim, on one hand we try to predict the future behavior of vehicles, because of stability routes depend on behavior of

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vehicles in VANETs. Besides, source estimates route stability Indicator (RSI) with fuzzy logic to select the 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 for a more stable path

2-reducing of network traffic and time for initiation route recovery.

The proposed scheme utilizes GPS location information [5], 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. The proposed routing algorithm is given in Section 2. In section 3, we do some simulations and present a comparative performance of Shortest Path (SP) with our algorithm. The conclusions are remarked in Section 4.

2. Algorithm Description

Before explaining the Algorithm, let us explain the assumptions we make about the network. We suppose that each vehicle is equipped with a positioning system, a GPS, allowing it to obtain its location. The coordinate of a vehicle i is denoted as Pi(xi, yi). Each vehicle can also calculate its speed, Vi. Links between vehicles are established if the distance between them is less than their transmission range R=200(m).

In this paper we present a new scheme to select the most stable route, using measuring the link stability and the distance of the vehicle from the sender. Our predictions rely on the consistent behavior of drivers; however, in the real world their behavior is not predictable. In another words, if a car selected as a relay suddenly accelerates and changes its speed, the route that depends on that relay will fail, independent of our prediction of the network stability. Solving this problem requires the prediction of the driver's behavior to some extent. We propose a new coefficient that reflects the stability of this behavior through time [9].

Drivers can show two types of behavior as they drive a vehicle on the road. First, they might keep their speed around a fixed point for a long time. For instance, by using a cruise control system, drivers can fix their speed at a certain point. The second scenario is that drivers change their speed frequently as time passes: they might speed up at a point and slow down after a short time.

To predict the behaviour of drivers, we monitor their manner, keep a history of them, and use this information to avoid selecting drivers with unstable driving behavior. For this purpose, we sample the speed of the vehicle through time, store and use the data to identify stable and unstable behaviors. For each vehicle we take n speed samples (V0, V1, . . . , Vn−1) every τ seconds during the time t0, t1, . . . , tn−1. As time passes, we move our sampling window forward to have the latest information about the behavior [9].

A stable driver is a driver who does not have many variations in speed and an unstable driver is a driver with lots of variations in speed. A coefficient of speed variations can be helpful to determine the type of driver. Let us assume that $\bar{v}$ is the mean of our current sampled data. We calculate the standard deviation s as

$$s = \sqrt{\frac{\sum_{i=0}^{n-1}(v_i - \bar{v})^2}{n}} \qquad (1)$$

The coefficient of variation represents the ratio of the standard deviation to the mean, and we use it to compare the

degree of variation in the speed of the driver. We calculate the coefficient of variation (CV) as follows:

$$CV = \frac{s}{\bar{v}} \qquad (2)$$

Also, if we keep the standard deviation fixed, the coefficient CV increases as the average speed decreases. Thus, the higher the variation in the speed, the longer the waiting time for the vehicle before it can rebroadcast the message.

So, if i and j are two adjacent nodes:

$$\Delta d_{i,j} = P_i - P_j \qquad (3)$$

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

$$CV = |CV_i - CV_j| \qquad (4)$$

Where CV denotes the behavior variations of two nodes i and j.

2.1 Route Stability Indicator (RSI)

Route Stability is resulted from Links Stability. The quality of fuzzy approximation depends on the quality of the rules. The result always approximates some unknown non-linear function that can change in time

The fuzzy logic proposed to calculate the Link Stability Indicator (LSI) of each link between source and destination. The two input variables to be fuzzified are Δd and CV of the neighbor nodes. The inputs are fuzzified, implicated, aggregated and defuzzified to get the crisp value of LSI as the output.

The linguistic variables associated with the input variables are Low, medium (MED) and high for Δd and Stable and Unstable for CV. For the output variable, link stability index, five linguistic variables are used. They are, very low (VL), low (L), medium (M), high (H) and, very high (VH). The table 1 shows the fuzzy conditional rules for the fuzzy stability. The first rule can be interpreted as, "If (Δd is low) and (CV is Stabel) then link stability is very high". Similarly the other rules have been developed.

Table 1. Fuzzy Rules

HIGH	MED	LOW	Δ d / CV
M	H	VH	Stable
VL	L	M	Unstable

Here, we use $LSI_{i,j}$ denote the LSI between node i and node j. Assume one communication route between source and destination is made up of n intermitted nodes.

$$RSI_{s,d} = LSI_{s,1} * LSI_{1,2} * LSI_{2,3} * \dots * LSI_{n,d}. \qquad (5)$$

$RSI_{s,d}$ denotes the Rout Stability Indicator of the whole route.

2.2 Route discovery

This process executes the path-finding algorithm to discover the stable route between source and destination. The source node initiates a route discovery process by broadcasting a Route Request (RREQ) message to all of its neighbor nodes in transmission range. 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 of RREQ. In this time window destination sends 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 their 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 calculates RSI while receiving first RREP and start to transmit data packet from discovered path, by receiving next RREPs, and compares their RSIs with transmitted packet route RSI. In this comparing if source finds route with higher RSI it will switch transmit packet path to stable path. In Fig. 2 node A is as source and G is as destination. Node A broadcasts RREQ to find existing routes. Node G when receives $RREQ_1$ sends $RREP_1$ without delay. Table 2 shows apparent routes between source and destination.

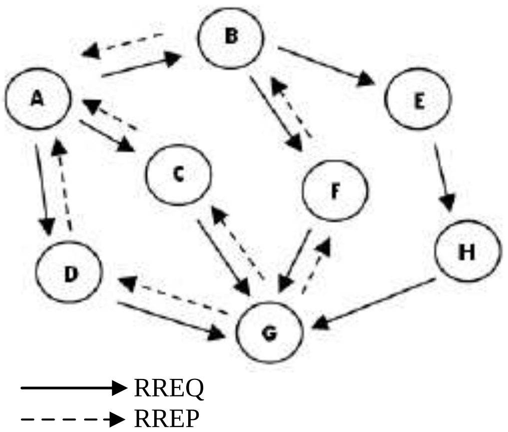

Figure 2. Example of Network

Table 2. Presentation Routes

RREQ Number	Discovery Path
RREQ1	A,D,G
RREQ2	A,C,G
RREQ3	A,B,F,G
RREQ4	A,B,E,H,G

So destination sends four RREPs to source. Source calculates RSI's after receiving RREPs. RSIs are shown in Table 3. Source starts to transmit data packet from route 1 after receiving $RREP_1$ and will switch to route 4 by receiving RREP4.

Table 3. Calculate RSI

RREP Number	RSI
RREP1	0. 259
RREP2	0. 208
RREP3	0. 206
RREP4	0.348

3. Performance Evaluation

In order to evaluate the performance of new algorithm based Most Stability Path First (MSPF), one famous open source network simulator VanetMobisim as a validated vehicular traffic generator is used for this study. The result from VanetmMobiSim gives a realistic mobility model that supports both micro-mobility or macro-mobility features. First, scenario characteristics are described briefly and then evaluation results are attempted which are obtained from these scenarios.

3.1 Simulation Environment

This simulation consists of two line streets with some intersections. Rectangular area covered by this simulation is 1000 × 1000 meter. Traffic signals are employed at intersection of streets. IDM-IM Intelligent Driver Model with Intersection Management and CBR is used as Mobility Model in this simulation, speed of mobile nodes/vehicles are set to 0 to 20 m/s in varying number of mobile nodes in range 10 to 40; each node has a transmission range of 200 meters. Time of simulation is 500 seconds.

Table 4. Simulation Parameters Settings

1000m×1000m	Terrain Range
Suburban	Type of Scenario
10-40	Number Of Nodes
0-20(m/s)	Nodes's Speed
500(s)	Simulation Time
IDM/IM and CBR	Mobility Model
Microscopic	Traffic Model
200(m)	Transmission Range

3.2 Performance Metrics

To evaluate the performance of MSPF routing Algorithm and comparison with Shortest Path Algorithm (SP), two main and very important performance parameters are considered:

A. Average Route Stability Indicator Minimum (Avg RSI-Min): Route stability is a very important performance parameter for a routing protocol .There is a route with the least stability in each tick time. This parameter calculates them average in total simulation time.

B. Average Route Length Minimum (Avg Length-Min): There is a route with the least length in each tick time. This parameter calculates them average in total simulation time.

3.3 Simulation Results

We present the performance of the proposed Most Stability Path First Algorithm (MSPF) in comparison with Shortest Path Algorithm (SP).

Fig. 3 shows the effect of different routing algorithms on route stability minimum. The route stability of two algorithms are increased and then decreased. SP shows the least path stability. X-axis represents the number of nodes and Y-axis represents the Average Route Stability Indicator Minimum, where we can see that route stability Indicator of MSPF is more than SP.

Fig. 4 shows the effects of different routing algorithms on network performance. As shown in Fig. 4, the Average Route Length Minimum of two algorithms decreases as the number of nodes increases. First, MSPF is lower than SP then with increasing number of nodes. Length of selected routes are equal in two algorithms.

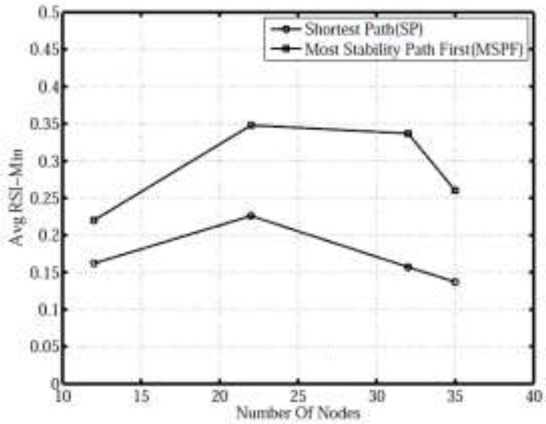

Figure 3. Average RSI Minimum various nodes

Now, we consider effects of two routing algorithms with increased time. As shown in Fig. 5, the Average Route Stability Indicator Minimum of two algorithms increases as the time increases and it in MSPF is more than SP. Figure 6 shows the most differences in Length of selected routes between two algorithm are in times 100 to 200(s) and also 400 to 500(s).We suppose that number of nodes are 12. These results show that in MSPF selected routes have more stability as well as the least length.

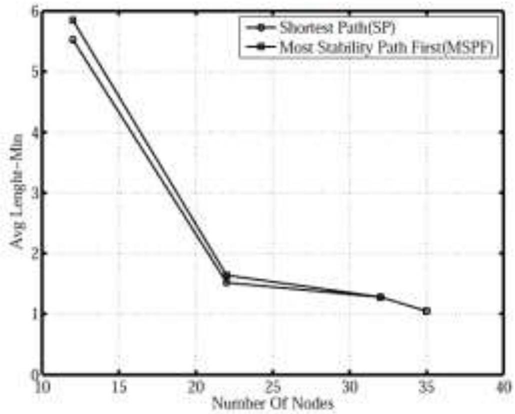

Figure 4. Average Length Minimum various nodes

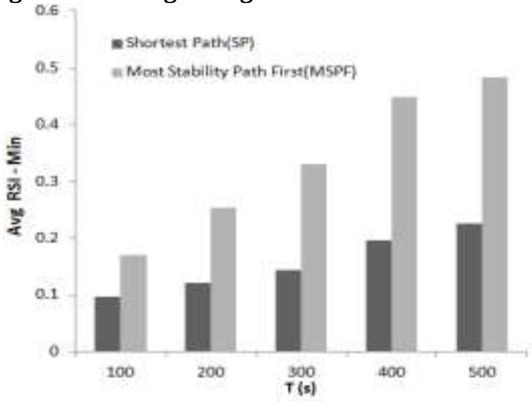

Figure 5. Average RSI Minimum various times

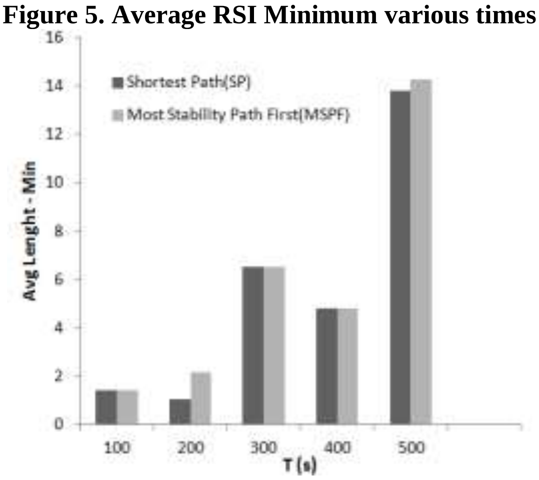

Figure 6. Average Length Minimum various times

5. Conclusions and future work

Vehicular ad hoc networks are full of uncertainties because of dynamic topologies, dynamic traffic and various application contexts. In this paper, we proposed a reliable and stable routing algorithm in vehicular ad hoc networks using fuzzy logic and estimate behavior of vehicles. This algorithm can be applied to most existing routing protocols, and it can greatly improve the route reliability and stability. It makes the communication in ad hoc networks more efficient and it helps to maintain better quality of the network. Currently the proposed algorithm considers only one criterion the stability when selecting routes. 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 apply in the vehicular ad hoc network routing decision. Innovation in this paper is source of selecting route using an important parameter. In summary it can be said simulation results show that the MSPF algorithm improves the performance and stability of VANET networks dramatically. We believe that the proposed protocol be able to decrease delay and increase packet delivery ratio that in the future work we will consider them for this algorithm.

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