Fuzzy Controller Based Stable Routes with Lifetime Prediction in MANETs

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Abstract

In ad hoc networks, the nodes are dynamically and arbitrary located in a manner that the interconnections between nodes are changing frequently. Thus, designing an effective routing protocol is a critical issue. In this paper, we propose a fuzzy based routing method that selects the most stable route (FSRS) considering the number of intermediate nodes, packet queue occupancy, and internodes distances. Also it takes the produced cost of the selected route as an input to another fuzzy controller predicts its lifetime (FRLP), the evaluation of the proposed method is performed using OMNet++4.0 simulator in terms of packet delivery ratio, average end-to-end delay and normalized routing load.

Keywords: MANET, AODV, Fuzzy Controller, Stable Route, Route Lifetime.

1. INTRODUCTION

An ad hoc network [1] is a particular type of wireless network, where a collection of nodes forming a temporary network without the aid of any established infrastructure, or support of any centralized administration such as a base station or an access point. Each node in such network behaves not only as a host but also as a router and takes part in discovery and maintenance of routes to other nodes.

Many routing protocols for MANETs have been introduced, the efforts in this area is that routing in such networks is a significant challenging task due to the frequently changing of the network topology.

To minimize link breakage and keeping the active routes lifetime, it is important to select the most stable route. Link stability indicates how stable the link is and how long it can support communication between two nodes; it basically depends on the distance between mobile nodes and buffer zone effect [2][3].

The route lifetime is the time for which the route is considered to be valid, too long route lifetime may leads to consider some routes as valid while they were broken. In contrast, too short lifetime may leads to remove some valid routes.
Due to the uncertainty nature of the node mobility and the estimation of link breakage, fuzzy logic has been applied to reduce the effect of these problems and improve the network performance. In the following section, we present some recently proposed methods concerning this area of research:

In A. Banerjee et.al. [4] method, a fuzzy controller named (RE) is embedded in every node to evaluate the performance of a link depending on residual energy ratio, neighbor affinity, and congestion if it was an intermediate node along the path to the destination, and if it was the destination it measures the performance of the last link then combines the performance of all the links and the hop count of that route to measure its performance to find the suitable route within a threshold time period.

While the method of S.H. Nasiri et.al. [5] Considers fuzzy nodes randomly distributed in the network, each has four inputs: number of neighbors, mobility factor of that node and its neighbors, and angle of movement to predict the link lifetime to be used by shortest path routing algorithm in selecting the next hop of the path.

E. Natsheh et.al. [6] proposed three methods to obtain fuzzy active route timeout in AODV routing protocol, where the fuzzy inputs in the first method was the number of hop count and number of control packets between two sampling interval, number of hop count and transmission power in the second method, while the last method takes the average of the results obtained from the previous two methods.

In this paper, we introduce a new method that merges these two ideas of using fuzzy controller to estimates the route cost and prediction of the route lifetime using fuzzy controller. The proposed method modifies the AODV routing protocol [7] within two stages, the first is called Fuzzy Stable Route Selection (FSRS) which selects the most stable available route based on fuzzy cost produced from three parameters: number of intermediate nodes, packet queue occupancy, and internodes distances in such a way [8] that reduces the routing discovery wait time by making each node along the path from the source to the destination participating in selecting the optimal route. While the second stage called Fuzzy Route Lifetime Prediction (FRLP) which predicts each route lifetime based on its fuzzy cost.

2. PROPOSED APPROACH

Our scheme incorporates two fuzzy controllers into each node, fuzzy controller <1> has three input metric to produce the path cost from the source to this node:

- Number of intermediate nodes
  The most popular metric used for selecting the route, since small number of intermediate nodes will have few chance of path breaking.

- Packet queue occupancy
  Routes not congested are more reliable, stable, and faster.

$$PQO = \sum_{hcnt=1}^{n} \frac{currentPQlength}{\max PQlength} \quad \ldots(1)$$

Where n denotes the number of nodes in that path, PQ denotes packet queue.

- Internodes distances

Short distance between nodes leads to high received signal strength, also the path with nearest neighbors are more stable since a small movement of any node located on the edge of other node's transmission may cause breaking in paths with far neighbors.

$$IND = \sum_{hcnt=1}^{n} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \quad \ldots(2)$$

Where ($x_{i,j}$,$y_{i,j}$) are the x,y coordinates of node i and its previous node j .
While the fuzzy controller <2> has only single input-single output which predicts the lifetime of the selected route from the source to the destination.

During the route discovery process of the AODV routing protocol, the Route Request (RReq) message carries the sum of the input parameters of fuzzy controller <1> in their entries, when a node along the path from the source to the destination receives this RReq msg. it will work as Fuzzy Stable Route Selection (FSRS):

- Measure the required parameters at the node itself and add them to the contents of the corresponding entries of the RReq msg. before forwarding it.
- Take these entries contents as inputs to the fuzzy controller <1> to produce the fuzzy cost of this individual path.
- Compare this fuzzy cost with the previous minimum fuzzy cost, if it is smaller it will save it for next comparisons and update the reverse route entry to the source of the RReq msg. with the address of the previous node.

This process will continue until getting the destination which sends the Route Reply (RRep) message on the generated route after predicting its lifetime (FRLP) by taken its fuzzy cost as input to fuzzy controller <2>.

3. SIMULATION MODEL

The simulation modeled a network in 700 m × 700 m area with 20 / 30 mobile nodes. Each node had a channel capacity of 54 Mbps. The IEEE 802.11g was used as the medium access control protocol. A random waypoint mobility model was employed with a speed ranging from 0 to 10 m/s. Eight mobile nodes acted as traffic sources generating data packets at a rate from 2 to 4 packets/sec, and the data traffic was generated using CBR (Constant Bit Rate), UDP application, each packet size was 512 bytes. The simulation was executed for 250 seconds of simulation time by OMNeT++ 4.0 simulator [9].

4. SIMULATION RESULTS

We compare the performance of AODV routing protocol, AODV routing protocol with FSRS, AODV with FSRS and FRLP in terms of:

- ***Packet Delivery Ratio*** :

$$PDR = \frac{\sum no.of\ rcvd.data\ pkts}{\sum no.of\ sent\ data\ pkts} \quad ...(3)$$

- ***Average End-to-End Delay***:

average time taken by data packets when released by sources until reach their destinations.

- ***Normalized Routing Load*** :

$$NRL = \frac{\sum no.of\ sent\ ctr.\ pkts}{\sum no.of\ sent\ data\ pkts} \quad ...(4)$$

From the simulation results in figures (1-3), the FSRS-AODV routing overcomes the performance of the original AODV routing, about 6.087%, 44.36%, and 10.113% improving in packet delivery ratio, End-to-End delay, and normalized routing load respectively, because of its ability to select more stable, less congested, and few failures routes. While more improvement in the network performance will be obtained when using FRLP-FSRS-AODV routing, about 7.18%, 53.247%, and 22.499% improving in packet delivery ratio, End-to-End delay, and normalized routing load respectively, due to less route errors and unnecessary route discoveries resulting in reducing control traffics, routing delay, and increasing packet delivery ratio.

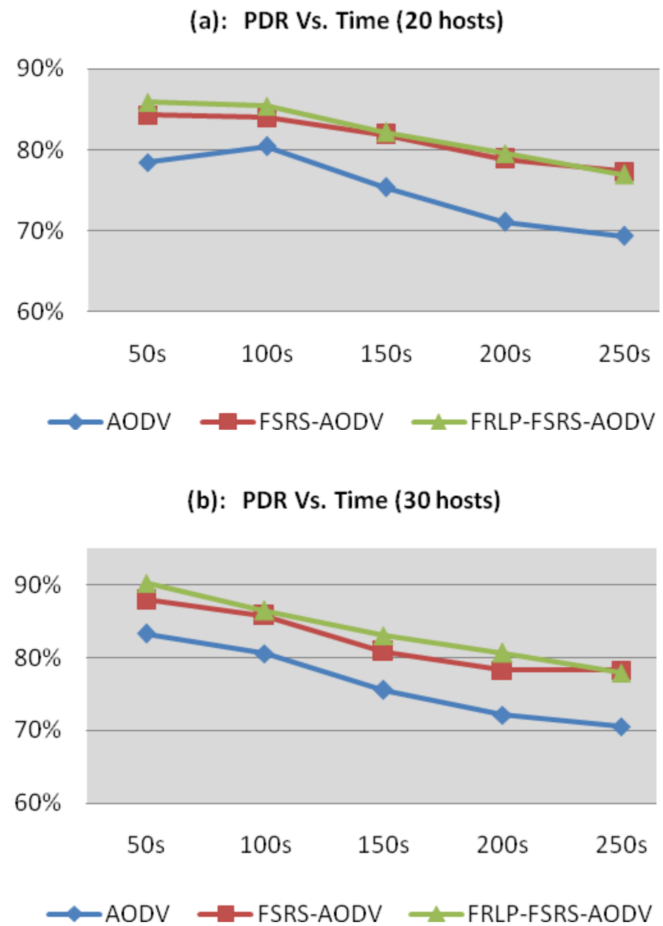
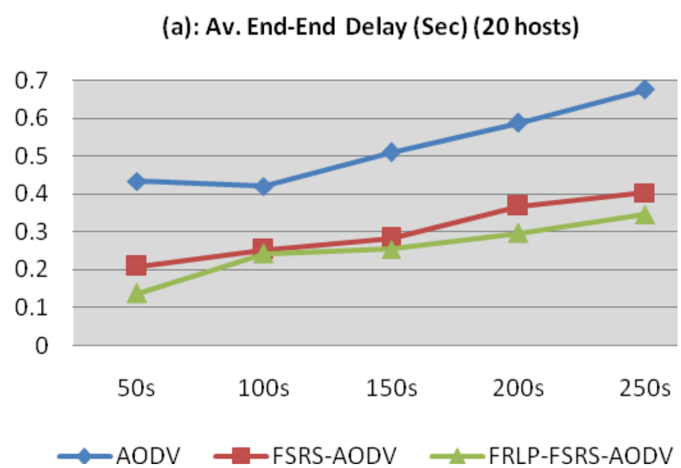


FIGURE (1): Packet Delivery Ratio vs. Time



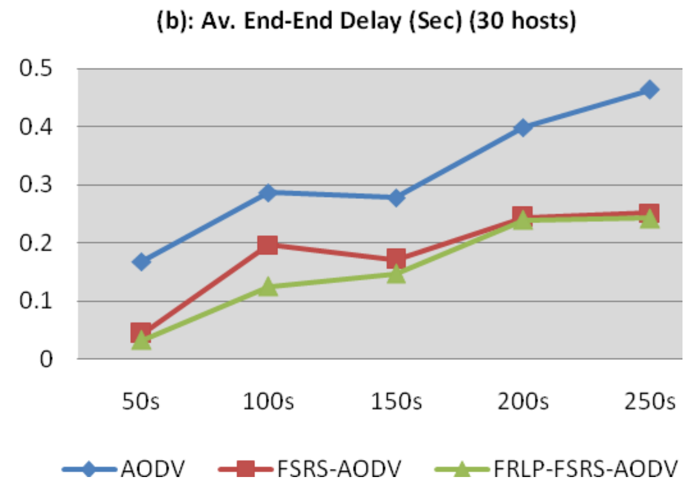
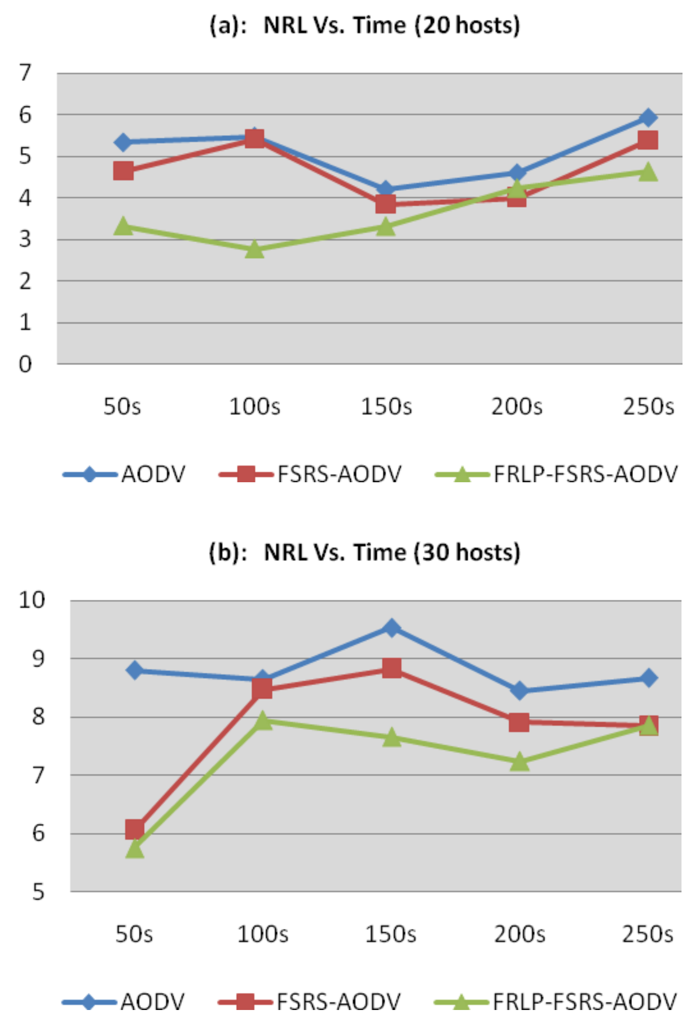


FIGURE (2): Average End-to-End Delay (Sec) Vs. Time



FIGURE(3): Normalized Routing Load vs. Time

5. CONCLUSION

In this paper, we used a fuzzy controller to obtain the routes cost depending on the number of intermediate nodes, packet queue occupancy, and internodes distances. And utilized this fuzzy cost to predict the lifetime of the selected routes using another fuzzy controller. The simulation results show that the proposed FSRS-AODV routing enhances the packet delivery ratio, average end-to-end delay, and normalized routing load when compared with the original AODV routing protocol indicating the stability of the selected routes. While more improvement will be obtained when adding FRLP indicating the suitable prediction of the selected routes lifetimes. Future work studies could take the impact of nodes mobility information that may improve the proposed method.

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