Routing in Fast-Moving Mobile Ad Hoc Networks

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Abstract

Because of each device is moving fast now. The speed of now is higher than past no matter what the processor speed of computer is, the transmit rate of network is, or transportation speed is. For example, the top speed of trains which some of countries can reach 200 kilometers per hour. Most of the existing ad hoc routing protocols do not work well if node speed is very fast. In this paper, we study the route breakage time and its correlation with node speed. A speed threshold for route stability is evaluated. Then, directional flooding protocol is found suitable in fast-moving mobile ad hoc networks. Directional flooding protocol is shown to have less overhead and better throughput through detailed simulations.

Keywords: *route breakage time, fast-moving MANET, directional flooding*

1. Introduction

In mobile ad hoc networks, each node is not only a host but also a router. However, mobility of nodes could result in route failure. In order to understand how mobility affects route stability. We study the relationship between route breakage and node speed. Furthermore, a speed threshold for route stability is evaluated. Then, various routing protocols including DSR, flooding, directional flooding and hybrid directional flooding are studied in fast-moving mobile ad hoc networks. Through simulations, directional flooding is found to have less overhead and to achieve higher throughput. Hybrid directional flooding achieves better performance when fast-moving and slow-moving nodes coexist.

The remainder of this paper is organized as follows. In Section 2, we study link breakage related to the node speed. Directional flooding and hybrid directional flooding are discussed respectively In Sections 3 and 4. Section 5 presents the simulation results. Section 6 is our conclusion.

2. Route breakage

In D'Souza's paper [2], time to propagate a routing information to the entire mobile ad hoc network is called τ. If the connectivity matrix of the mobile ad hoc network is known, the eigenvalue of the matrix could be used to evaluate τ. If the relative moving distance D is specified, link break boundary could be found. If the relative moving radius of nodes at some instant is r and the relative distance of nodes is R, the resultant relative distance for two nodes may be between two extreme cases, R-r and R+r, as shown in Figures 1 and 2, respectively. The worse case could be used to evaluate the speed threshold for route breakage as follows.

$$M = \frac{D}{\tau} \tag{1}$$

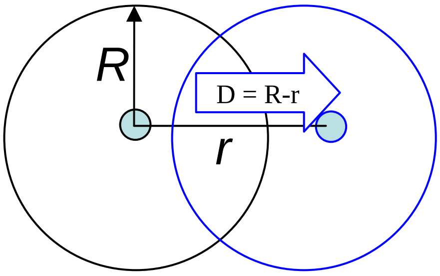


Figure 1 the worse case D = R - r

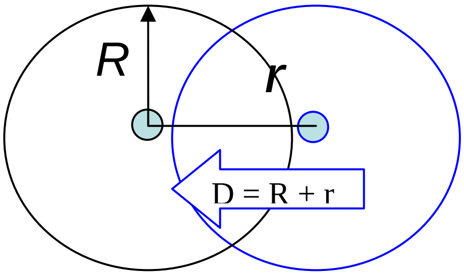


Figure 2 the best case D = R + r

Using the equation (1), a speed threshold could be evaluated. As shown in Figure 3, NS2 [4] simulation results show that the calculation of the speed threshold is accurate.

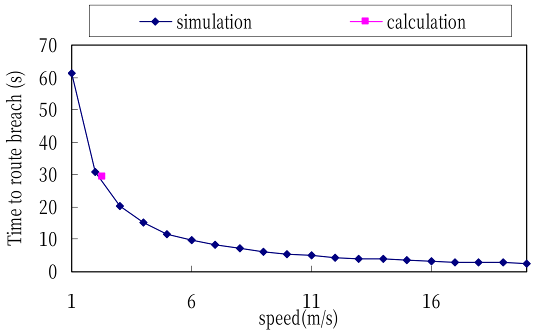


Figure 3 the route breakage speed threshold

3. Directional flooding

Flooding generates lots of duplicate packets. However, robustness of flooding is desirable for highly dynamic environment. To improve redundancy, directional flooding could be considered in fast-moving mobile ad hoc networks. This routing protocol exploits passing packets to collect information about positions of the other nodes.

Assume that each node knows its position. This could be done by GPS or the positioning scheme such as [1]. Then, a cache is needed to manage node direction information. We call this cache is directional cache. Each time receiving a packet, the node records the source of the packet and the position of the relaying node. If the directional cache doesn’t contain the destination information of its relayed packet, the packet is just flooded into the network.

4. Hybrid directional flooding routing

First of all, assume that the default routing is directional flooding routing. However, it is possible that some slow-moving nodes exist. It wastes too much to use flooding for theses nodes. Assume that each node knows its speed. The speed exceeds the route breakage threshold is call high mobility. On the other hand, the lower speed is called low mobility. Low-mobility nodes form a backbone-like structure. So, these nodes could organize to exchange the position information and avoid flooding in this backbone.

The flowchart of hybrid directional routing is showed in Figure 4. Initially, the source node wants to send packet, it has three choices.

1. We would use directional routing to send packet if source node is not slow node.
2. We would send packet with slowly moving routing table if source node is a low mobility node and it has destination information in the slowly moving routing table.
3. We would use directional routing to send packet if source node is a low mobility node but

it has no destination information in the slowly moving routing table.

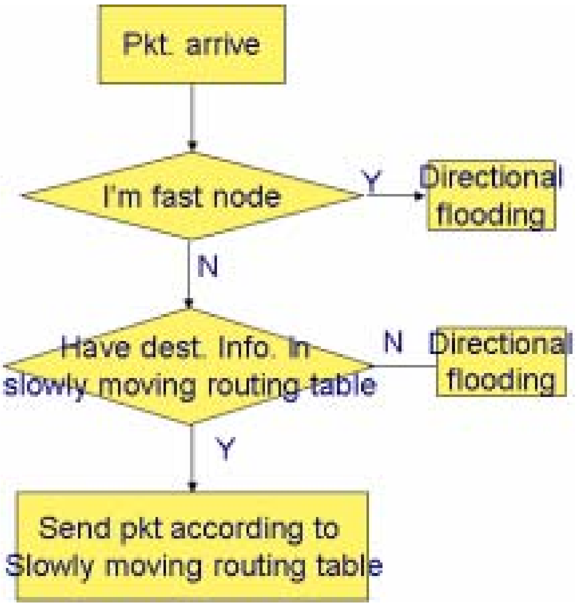


Figure 4 the flowchart of hybrid directional flooding routing.

5. Simulation

In this section, we describe an evaluation of the proposed directional flooding using simulations performed in ns-2 simulator [4]. We compare performance of flooding、directional flooding、hybrid directional flooding and DSR in our simulations.

A Simulation Setups

We illustrate our simulation environment and parameter setups are described in detail. We evaluate the performance of our proposed protocols in different mobility models. Our scenarios describe as follows.

(1) Free space: This simulation network has 1000*1000 meter*meter. We generate 50 nodes and uniform distribute on this network. Each node's speed is constantly varied. There are 20 UDP flows to transmit in our simulation time. The topology is shown in Figure 5.

(2) Freeway: This simulation network has 1000*160 meter*meter. There are 8 horizontal lanes in this network. Each lane has 20 meters wide. We generate 50 nodes and uniform distribute on this network. There are 80 meters toward Earth and 80 meters toward West. The nodes that locate on lanes of toward Earth just only move toward Earth. Each node's speed is constantly varied. There are 20 UDP flows to transmit in our simulation time. The topology is shown in Figure 6.

(3) Manhattan: This simulation network has 1000*1000 meter*meter. There are numbers of lanes of horizontal and vertical streets in this network. The topology is shown in Figure 7. The nodes just only locate on these lanes. The node may change its direction in the intersection but it won't go back to its original direction. Each node's speed is constantly varied. There are 20 UDP flows to transmit in our simulation time.

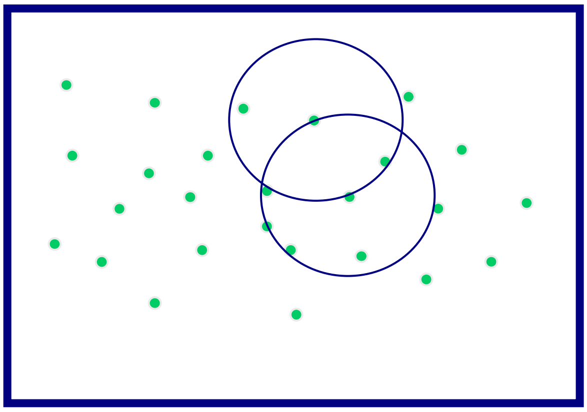


Figure 5 Free Space mobility model

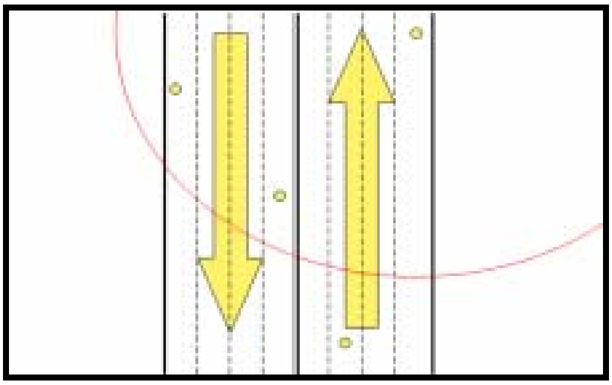


Figure 6 Freeway mobility model

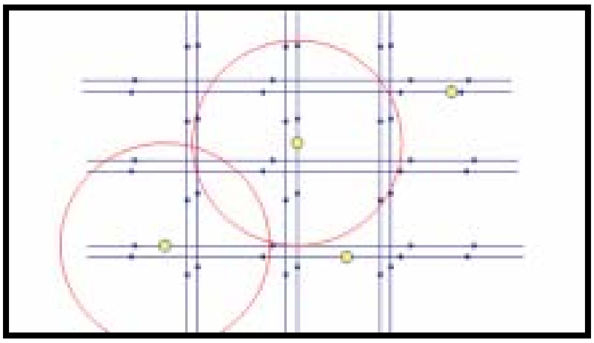


Figure 7 Manhattan mobility model

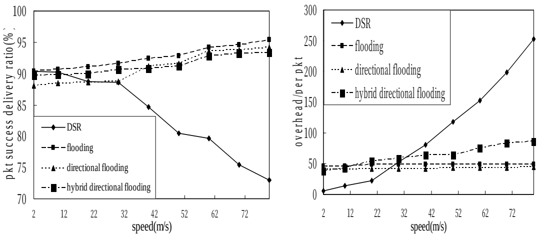
B simulation result

In this preliminary simulation, we compare performance with directional flooding、hybrid directional flooding、flooding and DSR in the three mobility models.

Figure 8a shows that throughput of each routing protocol in the free space mobility model. We see directional flooding is better than DSR when average speed 28 m/s (100.8 km/h) and upward. But the overhead of directional flooding is much more than DSR. Then we turn to see hybrid directional flooding. Clearly, hybrid directional flooding has good performance in low mobility and rises performance of directional flooding. But we observe the average speed 40 m/s. The performance of directional flooding is better than hybrid directional flooding in average speed range of 40 to 80. Why? Because of the hybrid directional flooding maintains slowly moving routing table. The information of slowly moving routing table is not really correct when the network speed is high.

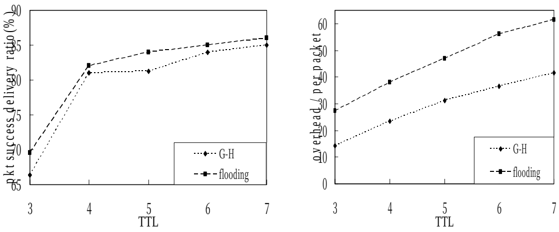
As described in Figure 8b, the overhead of DSR is less than directional flooding until average speed 35 m/s (126 km/h) and upward. Fig.9b also says the overhead of DSR routing protocol is fast to grow up when average speed is more than 20 m/s. and the overhead of hybrid directional flooding is more than hybrid directional flooding, because of enhance hybrid directional flooding maintains slowly moving routing table. We will get more overhead if we want to more correct information. The overhead of hybrid directional flooding has contained the number of update routing message in Figure 8b.

We want to compare flooding with directional flooding in the same TTL. And we show the results in Figures 9a and 9b. Clearly, directional flooding, in packet delivery ratio, is close to flooding; nevertheless the overhead is much lower than flooding.



(a) pkt. delivery ratio (b)overhead

Figure 8 Simulation in the Free Space

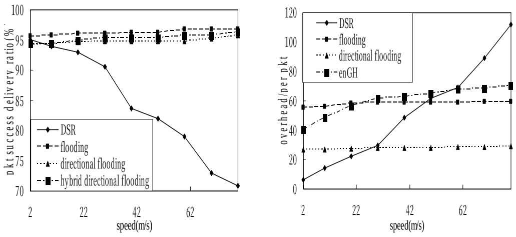


(a) pkt. delivery ratio (b)overhead

Figure 9 TTL for the Free Space

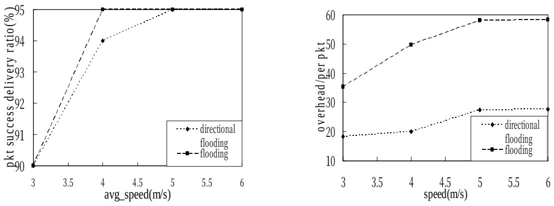
Next simulation, we similarly compare these routing in freeway mobility model. Because of nodes of this mobility model is restricted by space, these nodes just move two directions. In this situation, the performance can be different from other mobility models.

Figure 10a shows their packet delivery ratio is clearly higher than free space mobility model no matter what routing protocol is. Because the performance of directional routing depends on direction and the freeway mobility model is just two directions for transmitting, the performance will be higher than other mobility models. This property of freeway mobility is good for directional flooding, so it has high throughput. But it oppositely cause too much overhead. (Because of the directional cache's data and packet's data will be easy to conform). So we modify directional flooding when it works in the freeway mobility model. We reduce the number of broadcast packets to neighbors. Appropriately reduce the number of broadcast to neighbors can not affect performance. Figure 10b shows overhead of directional flooding for freeway, and the overhead is lower than others. Next, we see hybrid directional flooding has good performance, too. But the overhead of hybrid directional flooding is more than directional flooding. We suggest not using hybrid directional flooding in freeway mobility model. We should not consider DSR in Freeway mobility model. Figures 11a and 11b show the performance of directional flooding and flooding with the same TTL.



(a) pkt. delivery ratio (b)overhead

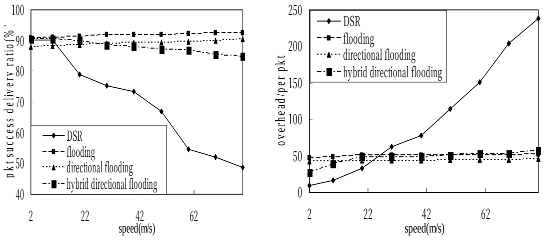
Figure 10 simulation in the Freeway



(a) pkt. delivery ratio (b)overhead

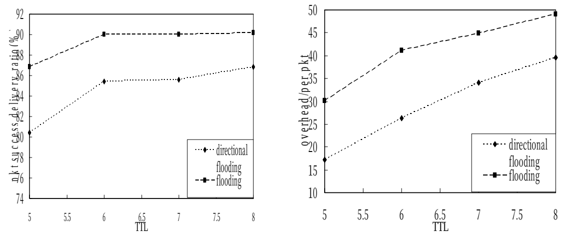
Figure 11 the TTL of GH for the freeway

Manhattan mobility model is also restricted by space, each node moves in specific lane and change direction at the intersection. This characteristic certainly incurs performance of mobility model lower than others. Figure 11a shows the performance of all routing protocol in Manhattan mobility model. Their performance in Manhattan mobility model is lower than other mobility models. The results shown in Figures 13a and 13b are similar to Figures 8a and 8b.



(a) pkt. delivery ratio (b)overhead

Figure 12 simulation in the Manhattan



(a) pkt. delivery ratio (b)overhead
Figure 13 simulation with TTL in the Manhattan

6. Conclusion

Mobility speed is shown to be very important for routing protocol. We evaluate route breakage threshold. If node speed is over this threshold, even DSR is hard to handle the route breakage. Only flooding or directional flooding could work well when node speed exceeding this threshold. Furthermore, hybrid directional could be used in an environment when high- and low-mobility nodes coexist.

7. Reference

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