The Probability of Link and Route Maintenance
In Multi Hop Mobile Ad Hoc Networks

Yong Shou Wu, Do-hyeon Lee, Eun Su Kim and Jae-il Jung
Department of Electronics Computer Engineering
Han Yang University
17 Haengdangdong, Sungdong-gu, Seoul
South Korea

Abstract: - Mobile ad hoc networks are being development quickly due to the availability of cheap 802.11 chips nowadays. A lot of algorithms are proposed to enhance the performance of mobile ad hoc networks. The main challenge in mobile ad hoc networks is mobility. Due to the moving node in the mobile ad hoc network, the route breaks frequently. In most of algorithms in the mobile ad hoc network, when constituting a route to destination node, the previous relay node will select as furthest node as possible to construct shortest path. The furthest node the previous node selects as the next hop relay node, the more possibly the link of the route will break in a short time. Researches need to be done in order to study the relation between the link and route maintenance probability and factors that affect the link and route maintenance probability. In this paper, we suggested the link maintenance probability model. And based on the link maintenance probability, route maintenance probability model was provided for mobile ad hoc networks.

Key-Words: - Multi Hop Manet, Link/Route Maintenance, Probability, Initial distance, Speed, Time.

1 Introduction
Ad hoc network constitute network with the help of other nodes in the same ad hoc networks and allows nodes in ad hoc network to send data with each other through a route which is consists of a number of nodes in the ad hoc network. Mobile ad hoc network can be applied in the fields of disaster rescue actions, battle fields and conference activity.

More than 10 years of works is devoted to study mobile ad hoc network and it is attracting more and more attentions these days. Lots of routing protocols for ad hoc network have been proposed to enhance the effectiveness and to reduce power consumptions. The routing protocols are mainly classified into three categories, proactive routing protocols, reactive routing protocols and hybrid routing protocols [1]. The first category of routing protocols are called proactive protocols, which computes all the path in advance regardless whether there is a packet to transmit or not. It is also called table driven routing protocol because these algorithms keep a table to update the routes periodically. Some of the well known proactive routing protocols include DSDV [2] and OLSR [3]. Second type of routing protocol is called reactive routing protocol which constitutes the route from source to destination reactively. These protocols are also called on demand routing protocol because these protocols only transmit packet on demand when there is a packet to transmit. Some of renowned reactive protocols include DSR [4] and AODV [5]. The third type of routing protocol is hybrid routing protocol which combine proactive routing protocol and reactive routing protocols. Typical examples hybrid routing protocol is ZRP[6] which maintains routes updates routing table periodically using proactive approach in zone and establish a route on demand through the inter zone.

Some researchers have proposed that with the help of position information, redundant messages, collisions and contentions can be avoided effectively. Routing protocols such as LAR [7] used location information in their protocols to limit the area. In these protocols, source node keeps the speed and location of destination node so that when the route breaks, the source node can calculate the
restricted zone where the route request packets to be transmitted.

The characteristics of mobility in ad hoc network cause route breaks often. So a new route discovery needs to be processed which introduces unnecessary route discovery delay and overhead. There are many factors that contribute to the route breakage such as time, speed of nodes in ad hoc network and the distance between two nodes, signal strength and obstacles in environment.

In this paper, we proposed a link and route maintenance probability model to study the relation between factors that affects the route breakage and link and route maintenance probability. The rest of the paper consists as follows. In the second section, we introduce the problem to be studied in this paper. The third section discusses the link maintenance probability model. In the fourth section, the route maintenance model is proposed. And we end up this paper with a short conclusion.

2 Problem Statement

In this section, we define the problem to be studied in this paper. As shown in figure 1, there are two nodes, node a and node b in the ad hoc environment. Node a locates in position A and node b locates in position B. We make the following assumptions that all the nodes in the network have the transmission range of $R$ and any of the two nodes are in the transmission range of each other, they can communicate and node b moves with maximum speed of $v$. But in reality, the transmission range may not be a circle, because the energy radiated by the nodes is not distributed equally in circle of its transmission range. Under these assumptions, node a is static while node b moves with its own speed, node a and node b are in the transmission range of each other initially. After $t$ seconds, node b moves away, at some point, node B may be out of the transmission range of node a, which results in link breakage. In this paper, we will derive link maintenance model according to speed of each node and time.

3 Link Maintenance Probability Model

In this section, the link maintenance probability model is derived according to problem statement definition. Under the considerations of the problem statement, we make the following conclusion that the probability $p$ that the two nodes, node a and node b can communicate after $t$ seconds is equal to equation (1).

$$p = (A_A \cap A_B) / A_B \quad (1)$$

In this link maintenance probability model (1), $p$ is the link maintenance probability, $A_A$ is the area of circle A, which has its center located at A and has a radius of $R$. $A_B$ is the area of circle B which has its center located at B and has a radius of $vt$.

Explanations for link maintenance probability model (1) are given below. Node b moves with a maximum speed of $v$ so that the locations where node a can appear after $t$ seconds are all the points on circle B. The probability that node b appears any point in circle B is equal. But, in order to communicate with node a after $t$ second, node b must locates with in circle A. So the positions where node b can appear is on circle B and the positions where b can communicate with node a is all the points within circle A. Consequently, the probability that node a can communicate with node b is the ratio of the overlapping area of circle A and circle B to the area of circle B.

4 Route Maintenance Probability Model

In this section, we will discuss the route maintenance probability model based on the link maintenance probability model. A route is composed of several links in multi hop ad hoc networks. Hop count plays an important part in the route maintenance. If the route is composed of a small number of hops that means the distance between the relay nodes must be large. So this increases the possibility of the link breakage. If the link breaks, the whole route breaks. But if a route is consisted of a large number of hops, which means the distance between two intermediate relay nodes are smaller so that the link is more stable. But if one of the links which constitute the route breaks, the whole route breaks. So
with more links, the possibility that one of the links breaks is increased. So we need a route maintenance probability model to study the relationship of hop count and route stability.

Link maintenance probability is related to route maintenance probability. We make the following assumptions that if the distance between source node and destination node is \( l \) and distance between two intermediate relay nodes is \( d \), then for the convenience of this study, we assume that the hop count of the route \( h \) is \( h = \frac{l}{d} \). In this circumstance, the link maintenance probability between two intermediate relay nodes is already derived to be \( p \) as described in the previous section. But the route was consisted of \( h \) hops, which means that there are \( h \) links between source and destination. Under these assumptions, the route maintenance probability model is derived as follow.

\[
P_R = p^h \tag{2}
\]

In the above route maintenance probability model (2), \( P_R \) denotes the route maintenance probability, \( p \) denotes the link maintenance probability and \( h \) is the hop count.

4 Conclusions and Future works

In this paper, we first analyzed the factors that will affect the link maintenance probability. Then we proposed the link maintenance probability model according to factors that impacts the link maintenance probability such as the speed of node and time. Based on the link maintenance probability, we proposed the route maintenance model according to the distance between two intermediate relay nodes in the mobile ad hoc network.

In the future, we will first verify the correctness of our approach by simulations. And then we will study the factors that affect the link and route maintenance probability. Finally, we will study algorithms to maximize the route maintenance time using the above observations.

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