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Procedia Computer Science 34 (2014) 565 – 570

Procedia Computer Science

International Symposium on Emerging Inter-networks, Communication and Mobility (EICM-2014)

A Link Quality Prediction Metric for Location based Routing Protocols under Shadowing and Fading Effects in Vehicular Ad Hoc Networks

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Abstract

The location-based routing protocol has been chosen as one of the efficient routing approaches in vehicular ad hoc networks in terms of low overhead and high scalability. Its critical advantage lies in performing a pathless routing such that a node having a packet forwards it to its neighbor node that provides the shortest physical distance to destination and this process continues until the packet reaches destination. The problem lies in that the link stability of the neighbors varies largely depending on the mobility of vehicles and the environmental factors that incur shadowing and fading effects. In this paper, we propose a new link quality prediction metric associated with location based protocols to improve the selection of next hop, that consider both the link quality assessment based on the transmission success rate and the link quality assessment based on the prediction of the future locations of vehicles. Simulation results are presented to demonstrate the efficiency of the proposed metric.

Keywords: Location based Routing Protocol; Link Quality; Forwarding Progress Distance, Vehicular Ad Hoc Networks

1. Introduction

Over the last two decades, much attention has focused on the application of mobile ad hoc network (MANET) technology to the Vehicular Ad Hoc Networks (VANETs) that consists of vehicles (nodes) with high mobility. The routing protocols designed for MANETs were tried for their application to VANETs with evaluation[1,2]. However, the effectiveness of those trials was limited due to the unique characteristics of VANET such as high node mobility, movement constraints, the mobility pattern of vehicles, and the road conditions with high building forest. Some location based routing protocols such as the GPSR[3], the CFG[4], and the GOAFR[5] tried to overcome these limitations. In these approaches, each node periodically broadcasts a hello message that includes its node identification number and the geographic location to its neighbors. Then, every node can maintain the geographical location information of its neighbors.

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doi:10.1016/j.procs.2014.07.071

Based on the geographical location information, a node having data packet chooses a neighbor node which provides the shortest physical distance to destination as next hop and then forwards the packet to the selected node. However, because of node mobility and hello interval, the selected node may have moved out of the transmission range of a sender, thereby breaking the corresponding link. One simple way of improving this problem is to decrease the hello interval so that every node can maintain more accurate motion information for its neighbors; however, it will increase control overhead. In addition, a link can be broken temporally due to variation of environmental factors such as path loss, shadowing and multipath fading. Consequently, if the next hop selection process does not take link quality into account, a forwarding node may frequently fail to forward a packet to the selected neighbor. As a result, a forwarding node may have to select next hop multiple times before forwarding data packet. Sometimes, it may exclude some node with a good link quality. This will degrade network throughput and increase packet end-to-end delay.

To resolve the two above mentioned problems, we propose a new link prediction metric that considers two link quality evaluation techniques - the past link quality is obtained from the link quality assessment based on the success rate of packets and the future link quality is obtained from the link quality assessment based on the prediction of the future locations of nodes. Then, next hop is selected by applying the combined link quality metric to each forwarding node. The past link quality is given in terms of the *Expected Transmission Count* (ETX) that indicates how many retransmissions have to be made before a forwarding node forwards a packet to next hop successfully. Whereas, the future link quality is given in terms of the *Predicted Forwarding Progress Distance* that is determined by the relative locations of a forwarding node and next hop. The mobility prediction mechanism[6] is employed to predict the future locations of a forwarding node's neighbors based on the motion information included in the last hello messages. Then, a node which is predicted to stay in the transmission range of the sender and has a good link quality will be given higher priority to be chosen as next hop.

The rest of the paper is organized as follows. In Section 2, we briefly review a radio propagation model. Then, we present some works related to link quality estimation and forwarding progress distance and describe a new quality metric in Section 3. In Section 4, the performance of the proposed approach is compared with those of some popular approaches. Finally, we make concluding remarks in Section 5.

2. Radio Propagation Model

The radio propagation model is used to predict the average signal strength at a given distance from a transmitter. Each radio propagation model of mobile radio system must reflect the effects of path loss, shadowing and multipath fading. While the path loss predicts the decay of the received power as a function of the distance between a transmitter and a receiver, and sometimes includes the effect of the antenna gains, the shadowing model considers effects of surrounding obstacles on the mean signal attenuation at a given distance. The multipath fading is caused by interference between multiple versions of the transmitted signal which arrive at a receiver at slightly different times.

In this paper, the *Groud Reflection* (2-ray) is used to model the path loss. This model is based on geometric optics and considers both direct path and a ground reflected propagation path between a transmitter and a receiver. The 2-ray path loss model is expressed in dB as follows[7].

$$PL(dB) = 10\log\left[\frac{d^4}{{h_t}^2{h_r}^2}\right] \tag{1}$$

where, h_t is the transmitter antenna height, and h_r is the receiver antenna height.

In addition, the log-normal distribution with a zero mean and a standard deviation σ describing the shadowing in dB is employed to model effects of shadowing. Therefore, taking into account the shadowing effects, the path loss of a transmitted signal at an arbitrary distance d in the far field region of the transmitter ($d > d_f$) is expressed as follows[7].

$$PL(d) = PL(d_0) + 10n\log\left(\frac{d}{d_0}\right) + X_\sigma \tag{2}$$

where, $PL(d_0)$ is the path loss in dB at a reference distance d_0, n is the path loss exponent, and X_σ is a zero-mean Gaussian distributed random variable with standard deviation σ