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A position-based routing protocol for vehicular ad hoc networks in a city environment

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Abstract

Vehicular Ad Hoc NETworks (VANETs) is a form of Mobile Ad hoc NETworks (MANETs) which provides a distinguished approach for Intelligent Transport System (ITS). The most challenging task in VANETs is the routing of data. This is due to the high mobility of the vehicles which induces a rapid change in the network topology. Research in the area of VANETs routing protocols have shown that position-based routing is well adapted for highly dynamic environments such as inter-vehicle communication on highway environments. However, position-based routing finds difficulties to deal with two-dimensional scenarios with obstacles (building, tree, etc), which blocked radio transmissions, and voids as it is the case for city environments. Thus, in this paper we propose a position-based routing approach for Vehicular Ad hoc NETworks which attempts to deal with obstacles and voids found in a city environment.

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Keywords:
Vehicular Ad hoc NETworks (VANETs); Position-based routing; Greedy forwarding; Obstacles; City environment.

1. Introduction

Vehicular Ad hoc NETworks is a sub class of Mobile Ad hoc NETworks design to improve traffic safety and travel comfort of drivers and passengers.

One of the principal issues that affect the performance of the Mobile Ad hoc NETworks is routing. Research in the area of VANETs routing have found that position-based routing for MANETs is a very promising routing strategy for Inter-Vehicular Communication. However, routing of data in a vehicular ad hoc network is a challenging task due to the characteristics of VANETs. The most important one is the high mobility of the vehicles which induce a high dynamics change in the network topology.

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Traditional MANETs routing protocols fail to wholly address the specific characteristics and requirements of VANETs especially in a city environment, such as the nodes distribution which is not uniform, the high mobility of the node, the signal transmissions blocked by obstacles, etc. To address these specific needs of VANETs, many position-based routing protocols have been proposed. Among them, GPSR [1], GSR [2], A-STAR [3], GPCR [4], LOUVRE [5], VADD [6], RRP [7], DPPR [8], RPS [9], etc. However, these protocols suffer from some limitations. Indeed, improved protocols are often based on a simple greedy forwarding approach (closest neighbor to the destination) and do not take into account neither the radio obstacles (building, trees, ...) which block radio signals nor the density traffic vehicles in the network.

In this paper, we propose a novel routing approach for Vehicular Ad hoc NETworks in a city environment which attempts to address these lacks.

The paper is organized as follows: Section 2 reviews some previous works on position-based protocol for VANETs. Section 3 presents the proposed routing approach. In section 4, we present the simulation study that compares our routing approach with a classical ad hoc routing method 'AODV' (Ad hoc On-Demand Distance Vector) [10] and with GPCR a well-know position-based protocol. Section 5 concludes the paper with some perspectives for possible future improvement of our approach.

2. Related works

To deal with the rapidly changing network topology of VANETs, position-based protocols have been proposed that are based on geographic information. A node makes packet forwarding decisions only based on the location of itself, its neighboring nodes, and the destination node. So, a node forwards the packet to the direct neighbor which is the closest to the destination than itself. This strategy is called *greedy forwarding* or *geographic forwarding*. However, this strategy can fail when there is no neighbor available that is closer to the destination node than the current forwarder node. This situation is called a *local optimal* and a recovery method should be used. Several recovery strategies are proposed in the literature like *Perimeter mode* in Greedy Perimeter Stateless Routing [1] (GPSR).

GPSR [1] is the most known and cited position-based protocol. To overcome from a local optimal, it uses the well-know *right-hand rule* recovery strategy. Thus, locals optimal and link breakage problems can be recovered by perimeter mode forwarding. However, packet loss and high delay time may result because the number of hops is increased by perimeter mode forwarding. This reduces considerably the reliability of GPSR.

Geographic Source Routing (GSR) [2] forwards packets according to the forwarding path, which is calculated based on coordinate location and placement on the road-map of the vehicles. However, this protocol fails to deal with the sparse connectivity problem when the vehicle density on road is too low.

Anchor-based Street and Traffic Aware Routing (A-STAR) [3] uses a static street map to route packets around potential radio obstacles such as city buildings. In order to take advantage of the fact that some streets contain denser traffic than others, A-STAR uses information on city bus routes to identify an anchor path with high connectivity for packet delivery. However, the concept of constant traffic information is only available in large cities.

Greedy Perimeter Coordinator Routing (GPCR) [4] forwards packets along the road according to the vehicle movement. All packets are given first priority to be forwarded to a junction node (a node located at a junction) in order to determine the next hop. However, since GPCR does not use any external static street map so nodes at intersection are difficult to find.

Vehicle-Assisted Data Delivery (VADD) [6] is based on the idea of carry-and-forward strategy and by the use of predictable vehicle mobility, which is limited by traffic model and road structure. Based on the existing traffic model, a vehicle can find the next road to forward the packet to reduce the delay. However, due to the dynamic nature of the VANETs and to the traffic density it may cause a large delay delivery.

Reliable routing protocol (RRP) [7] identifies more reliable paths by predicting the existence of candidate relay nodes when the link expiration time passes. If the vehicle cannot identify a candidate relay node (that is, if it realizes that a routing hole occurred on the current link), then the data is rerouted to a different block.

Driving Path Predication Based Routing (DPPR) [8] can observably increase the successful ratio to find the proper next hop vehicles that move toward the optimal expected road in intersection areas. In roads with sparse vehicle density, DPPR utilizes vehicles to carry packets to roads with high vehicle density. Moreover, as to packets that can tolerate long delay, they can be carried to destinations by vehicles whose driving paths will pass the packets destination