Chapter VII
Inter-Vehicular Communications Using Wireless Ad Hoc Networks

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ABSTRACT

This chapter proposes a new routing algorithm that allows communication in vehicular ad hoc networks. In vehicular ad hoc networks, the transmitter node cannot determine the immediate future position of the receiving node beforehand. Furthermore, rapid topological changes and limited bandwidth compound the difficulties nodes experience when attempting to exchange position information. The authors first validate their algorithm in a small-scale network with test bed results. Then, for large-scale networks, they compare their protocol with the models of two prominent reactive routing algorithms: Ad-Hoc On-Demand Distance Vector and Dynamic Source Routing on a multi-lane circular dual motorway, representative of motorway driving. Then the authors compare their algorithm with motorway vehicular mobility, a location-based routing algorithm, on a multi-lane circular motorway. This chapter then provides motorway vehicular mobility results of a microscopic traffic model developed in OPNET, which the authors use to evaluate the performance of each protocol in terms of: Route Discovery Time, End to End Delay, Routing Overhead, Overhead, Routing Load, and Delivery Ratio.
INTRODUCTION

How to best optimize traffic flow is one of the primary challenges of specialists studying congestion and safety on streets and motorways because of the economic, health, and safety issues related to inefficient traffic circulation. Proposals to mitigate traffic congestion, caused in part by inefficient traffic flow, have often included expensive construction projects. These projects, however, have had only limited success. In the United States, for highway travel congestion of personal vehicles, the Transportation Statistics Annual Report (2006) states that “highway travel times increased between 1993 and 2003 in all but 3 of the 85 urban areas (98 percent)”, and “it took 37 percent longer, on average, in 2003 to make a peak period trip (from 6 to 9 a.m. and 4 to 7 p.m.”. Additionally, this same report reveals that “there were nearly 45,000 fatalities in transportation accidents in the United States in 2004, of which 95 percent involved highway motor vehicles”. Furthermore, although the number of fatalities slightly decreased, “in 2005, 43,443 motorists and non-motorists were killed in crashes involving motor vehicles, up 1% compared with 2004, and about 2.7 million people were injured”. Finally, the report mentions that “there were 1.47 fatalities per 100 million vehicle-miles of highway travel in 2005”.

Although passive safety systems such as seat belts and air bags have been used to significantly reduce the total number of major injuries and deaths due to motor vehicle accidents, they do nothing to actually improve traffic flow or lower the actual number of automobile collisions. In order to reduce the number of vehicular accidents, computer and network experts propose active safety systems, including Intelligent Transportation Systems (ITS) that are based on Inter-vehicular Communication (IVC) and Vehicle-to-Roadside Communication (VRC). Presently, technologies related to these architectures and their related technologies may, in the future, more efficiently administer traffic flow, which, in turn, can have important safety, ecological, and economic ramifications.

Active vehicular systems employ wireless ad hoc networks and Global Positioning System (GPS) to determine and maintain inter-vehicular distances to insure the one-hop and multi-hop communications network needed to maintain vehicle spacing. Location-based routing algorithms may help in the development of Vehicular Ad Hoc Networks (VANETs) because their flexibility and efficiency provide the ad hoc architecture necessary for inter-vehicular communication. Although several location-based algorithms already exist, including Grid Location Service (GLS), Location Aided Routing (LAR), Greedy Perimeter Stateless Routing (GPSR), and Distance Routing Effect Algorithm for Mobility (DREAM), to name just a few, we propose a Location-Based Routing Algorithm with Cluster-Based Flooding (LORA-CBF) as an option for present and future automotive applications (Santos et al., 2005).

Ad Hoc routing protocols have the design goals of network optimality, simplicity, low overhead, robustness, stability, rapid convergence, and flexibility. However, since mobile nodes suffer from significantly less available power, processing speed, and memory, low overhead becomes even more important than in conventional fixed networks. The high mobility present in vehicle-to-vehicle communication also places great importance on rapid convergence. Therefore, it is imperative that ad hoc routing protocols effectively compensate for any inherent delays in the underlying technology, adapt to varying degrees of mobility, and be sufficiently robust to deal with potential transmission loss due to drop out. Additionally, such protocols must more effectively route packets than traditional network algorithms in order to effectively compensate for limited bandwidth resources.

Several routing algorithms for ad hoc networks have emerged recently to address difficulties related to unicast routing. Such algorithms can
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