Chapter 12
Probabilistic Information Dissemination in Vehicular Ad Hoc Networks

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ABSTRACT

Many of the applications in VANETs, especially the safety related ones, set up requirements for information dissemination which are different from conventional networks and are thus difficult to fulfill with existing strategies. In this chapter, we review recently proposed data dissemination schemes in VANETs and we present novel solutions and analytical evaluation tools. We focus on the use of probabilistic methods as these are known to provide effective solutions and at the same time address the highly stochastic nature of many of the processes involved in VANETs. We present a short range multi-hop broadcast scheme which employs speed adaptive probabilistic flooding to overcome the broadcast storm problem in the case of high traffic density, a hovering scheme which employs probabilistic flooding to overcome the intermittently connected nature of the network within the hovering area and finally, we establish analytically lower bounds on the probability of information propagation at an intersection taking into account the vehicle speeds and the traffic density which is reflected in the vehicle arrival rate.

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INTRODUCTION

Intelligent Vehicle Systems (IVSs) employing vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communications harness the potential of information and communication technologies (ICTs) to create a safer, smarter and more efficient transportation network. The rapid growth in transportation needs and car ownership has led to a severe increase in road traffic which has generated a number of social and economic problems: congestion of road transportation networks, environmental hazards and above all traffic accidents. On an average day in Europe (U.S.), vehicle collisions kill more than 100 (116) people and injure 4600 (7900). Government agencies and automotive industries are responding by investing billions of dollars in an effort to reduce these terrifying numbers. Intelligent Transportation Systems (ITS) are considered central cornerstones of this effort and vehicular ad hoc networks (VANETs) are emerging as the preferred network design for ITS technologies. The recently published 802.11p standard supports both vehicle-to-vehicle and vehicle-to-infrastructure communications allowing the formation of vehicular ad hoc networks which are envisioned to accommodate the new generation of cooperative safety applications. The range of applications of VANETs goes beyond the safety related ones to include traffic monitoring, platooning, text messaging, distributed passenger teleconferencing, music downloading, roadside e-advertisements etc.

Many of the aforementioned applications in VANETs, especially the safety related ones, set up requirements for information dissemination which are different from conventional networks and are thus difficult to fulfil with existing strategies. Safety applications pose stringent delay requirements on emergency message delivery and address geographical areas in which data needs to be cooperatively collected, distributed and maintained. Design challenges are then posed by the variable node density along the transportation network, the high mobility, the confined but often unpredictable movement and the unreliable radio channel. Variations in traffic density are of particular importance as low traffic densities cause the network to become intermittently connected whereas high traffic densities lead to excessive contention. These phenomena significantly degrade the performance of data dissemination strategies whether these are routing protocols or broadcast based schemes. In this chapter, we review recently proposed data dissemination schemes and we present novel solutions and analytical evaluation tools which address the aforementioned problems. We focus on the use of probabilistic methods as these are known to provide effective solutions and at the same time address the highly stochastic nature of many of the processes involved in VANETs. We present a short range multi-hop broadcast scheme which employs speed adaptive probabilistic flooding to overcome the broadcast storm problem in the case of high traffic density, a hovering scheme which employs probabilistic flooding to overcome the intermittently connected nature of the network within the hovering area and finally, we establish analytically lower bounds on the probability of information propagation at an intersection taking into account the vehicle speeds and the traffic density which is reflected in the vehicle arrival rate. Simulation results which are outlined in the Chapter validate our analytical findings and indicate that the proposed protocols satisfy to a very good extent the posed design objectives.

The chapter is organized as follows. In section 2 we review recently proposed data dissemination schemes, in section 3 we present the Speed Adaptive Probabilistic Flooding scheme, in section 4 we demonstrate the effectiveness of Gaussian like Probabilistic Flooding for information hovering, in section 5 we derive a formula which calculates lower bounds on the probability of message propagation on intersections and finally in section 6 we offer our conclusions and future research directions.