Chapter 12

Information Dissemination in Urban VANETs: Single-Hop or Multi-Hop?

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ABSTRACT

In recent years, Vehicular Ad-hoc NETworks (VANETs) have experienced an intense development phase, driven by academia, industry, and public authorities. On the basis of the obtained results, it is reasonable to expect that VANETs will finally hit the market in the near future. In order to reach commercial success, VANETs must effectively operate during the first years of deployment, when the market penetration rate will be unavoidably low, and, consequently, only a small number of suitably equipped vehicles (VANET-enabled) will be present on the roads. Among the possible strategies to face the initial sparse VANET scenarios, the deployment of an auxiliary network constituted by fixed Road Side Units (RSUs), either Dissemination Points (DPs) or relays, is certainly one of the most promising. In order to maximize the benefits offered by this support infrastructure, the placement of RSUs needs to be carefully studied. In this chapter, the authors analyze, by means of numerical simulations, the performance of an application that leverages on a finite number of DPs for disseminating information to the transiting vehicles. The positions of the DPs are determined through a recently proposed family of optimal placement algorithms, on the basis of proper vehicular mobility traces. The analysis is carried out considering two realistic urban scenarios. In both cases, the performance improvement brought by the use of multi-hop broadcast protocols, with respect to classical single-hop communications with DPs, is investigated.

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INTRODUCTION

Nowadays, most of the vehicles moving on our streets are powerful mobile computing devices, with sensorial, computational, and cognitive capabilities. Moreover, in the near future they will likely possess wireless communication capabilities as well, in order to exchange data with existing wide area networks (e.g., cellular networks) and to implement Dedicated Short-Range Communications (DSRCs) with the surrounding vehicles. The possibility of creating decentralized and self-organized vehicular networks, commonly denoted as Vehicular Ad-hoc NETworks (VANETs), is one of the most appealing applications which will be enabled by the exploitation of “smart vehicles.”

It is widely recognized that the implementation of effective VANET-based services is a complex task, for several reasons:

1. The highly dynamic network topology, due to high vehicle mobility;
2. The severe fading that often characterizes the wireless communication channel;
3. The plethora of services with different requirements that may be supported in VANETs, ranging from safety-critical applications, with strict latency and reliability requirements, to bandwidth-consuming infotainment applications;
4. The large spectrum of traffic conditions that occurs in real roads, ranging from fluid traffic flow situations (as it happens in rural areas or during the night-hours) to jammed urban roads or congested freeways.

Historically, most of the research efforts have been focused on dense networks, with the aim of designing efficient and congestion-avoidance forwarding protocols. However, lack of connectivity in sparse networks will be the first critical issue to be addressed by VANET-based commercial communication systems. In fact, during the first years of deployment the market penetration rate of the inter-vehicular communications technologies will be unavoidably low, thus yielding to scenarios where VANETs will be typically sparse.

Among the possible approaches to avoid the lack of connectivity, the deployment of a complementary network infrastructure, constituted by fixed network nodes, is one of the first feasible solutions. These fixed nodes, denoted as Road Side Units (RSUs), are commonly equipped with the same communication technology of the vehicular mobile nodes. The RSUs can play different roles, acting as Disseminating Points (DPs) or relays. In the first case, we assume that a DP generates “new” information to be disseminated in a spatial region around itself—the size of this region depends on the communication strategy (either single-hop or multi-hop), as will be shown later. DPs are inter-connected by means of a backbone network constituted by either wireless or wired communication links. Since the backbone capacity is typically much higher than that of a VANET, it is reasonable to assume that a given information (generated by a control center) will be simultaneously available at every DP. In the second case, a relay actively participates to the forwarding process, by relaying the received packets a single time or by storing them for a certain finite time, periodically broadcasting them (store-and-forward). In this case, relays act as independent entities, without requiring to be connected to a backbone infrastructure.

On the basis of the considerations above, it emerges that RSUs will be highly instrumental to a successful commercial deployment of VANETs. In order to be cost-effective and to guarantee a significant improvement, in terms of Quality of Service (QoS), the number and the placement of the RSUs need to be properly optimized. However, despite the importance of this issue, to date a small number of works has addressed it.

In this chapter, we focus on the problem of optimizing the dissemination of information from a group of DPs to the vehicles in an urban scenario. We take into account a push transmission
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