Chapter 79
RSU Deployment for Content Dissemination and Downloading in Intelligent Transportation Systems

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ABSTRACT

The focus of this chapter is twofold: information dissemination from infrastructure nodes deployed along the roads, the so-called Road-Side Units (RSUs), to passing-by vehicles, and content downloading by vehicular users through nearby RSUs. In particular, in order to ensure good performance for both content dissemination and downloading, the presented study addresses the problem of RSU deployment and reviews previous work that has dealt with such an issue. The RSU deployment problem is then formulated as an optimization problem, where the number of vehicles that come in contact with any RSU is maximized, possibly considering a minimum contact time to be guaranteed. Since such optimization problems turn out to be NP-hard, heuristics are proposed to efficiently approximate the optimal solution. The RSU deployment obtained through such heuristics is then used to investigate the performance of content dissemination and downloading through ns2 simulations. Simulation tests are carried out under various real-world vehicular environments, including a realistic mobility model, and considering that the IEEE 802.11p standard is used at the physical and medium access control layers. The performance obtained in realistic conditions is discussed with respect to the results obtained under the same RSU deployment, but in ideal conditions and protocol message exchange. Based on the obtained results, some useful hints on the network system design are provided.

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INTRODUCTION

In most countries the time that a person spends in a car ranges between one and two hours per day. Thus, most carmakers are striving to create an in-vehicle environment which is as comfortable and entertaining as possible. Most newly manufactured vehicles boast multimedia capabilities that were once thought to belong to a living room, like LCD screens or gaming consoles. Such technological wealth, however, is not complemented with live features besides radio broadcasts. The presence of multiple LCD screens for passengers begs, as it were, for advanced infotainment services of various nature, ranging from email/social network access to more bandwidth-demanding contents, such as newscasts or local touristic clips. Without affecting drivers' attention, navigational aids may be integrated by short videos showing traffic congestion and recommending alternate routes. Furthermore, in keeping with the explosive growth of social networks, it is envisioned that car passengers may show a high interest in car-oriented social networking and multiplayer games. Finally, professional drivers could access services for efficient vehicle fleet coordination, up-to-the-minute updated goods deliveries or re-routing, and customized cab pick-ups.

Currently, the only connectivity option for vehicles amounts to accessing a 3G network, which could provide high-speed network availability but is hampered by restricted competition among network operators. In addition, the lack of a local infrastructure, which is specifically dedicated to geolocalized services, makes the realization of the above scenarios hard to implement and limits its features. However, the emergence of communication standards for vehicular networks is bringing new visions and opportunities that could come close to the always-connected paradigm. Globally referred to as Intelligent Transportation System (ITS), this new vision aims at improving transportation in terms of safety, mobility, traffic efficiency, impact on the environment, and productivity.

Motivated by such a vision, this Chapter deals with the dissemination of information from RSUs to vehicular users within a geographical region, as well as the downloading from RSUs of delay-tolerant (e.g., map services, touristic information) and bandwidth-demanding (e.g., video streaming) content, by passing-by vehicles. More specifically, the presented study tackles the issue of deploying an ITS infrastructure based on the IEEE 802.11p technology, which efficiently achieves the goal of information dissemination and downloading in spite of the fleeting connectivity, highly dynamic traffic patterns, and constrained node movements. To this end, the following key issues are investigated:

1. Assuming that an area, with an arbitrary road topology, must be equipped with a limited number k of infrastructure nodes, what is the best deployment strategy to maximize the dissemination process or the downloading throughput?
2. Given such an optimal RSU deployment, what is the actual throughput performance that can be achieved by users when realistic traces are used to represent the vehicular mobility?

The answers to the above questions are given in the remainder of the Chapter, which is organized as follows.

- The section entitled "Background" reviews existing approaches to the problem of optimal RSU deployment, and discuss them by highlighting the differences and the performance they can achieve.
- In the section entitled "RSU Deployment for Content Dissemination and Downloading," different formulations of the infrastructure deployment problem are presented. The most complete one, referred to as Maximum Coverage with Time Threshold Problem (MCTTP), aims at guaranteeing

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