Abstract

Vehicular networks are essentially communication networks in which each vehicle equipped with a radio interface communicates with other vehicles or network infrastructure nodes, e.g., Road Side Units (RSUs) and Base Stations (BS), and thereby support a wide range of practical applications, such as safe and controlled driving, traffic monitoring, autonomous or assisted driving, etc. Service provisioning for such applications is extremely challenging due to vehicular movements causing drastic network topology and communication quality changes. However, the envisioned vehicular applications are multifarious that require diverse service provisioning. In order to support these applications, it is necessary to design appropriate solutions.

In this thesis, we strive for improved service provisioning in next-generation vehicular networks. We first propose a novel unicast vehicle-to-vehicle (V2V) routing based on Fuzzy Logic that consolidates competing cross-layer and positional information to make enhanced routing decisions. Such unicast routing is critical for a few vehicular applications, e.g., responding to requests but ineffective when the goal is fast dissemination of information to all nearby vehicles. Therefore, we next propose an efficient message dissemination scheme based on V2V communication. To this end, each vehicular node gathers its two-hop neighborhood information to identify the designated nodes responsible for the dissemination process.

Recognizing that only V2V communication cannot support the service requirements of next-generation vehicular applications, we next focused on infrastructure-assisted vehicular networks, with a particular emphasis on efficient network infrastructure planning. We used long-term vehicular traffic distribution to address cost-efficient edge node placement under a budget constraint. Additionally, we proposed a cost-effective deployment of millimeter wave-enabled RSUs (mmRSUs) in a smart city under a budget constraint. By leveraging real-world vehicular traffic, we validated the effectiveness of the proposed solutions. We also recognized that simply placing network infrastructure nodes is inadequate, but these need to be connected among themselves. Thus, we defined a cost-efficient network infrastructure design problem in an urban vehicular context and proposed a solution by employing an appropriate heuristic technique to provide critical insights.

Upon dealing with real-world vehicular data, we realized that vehicular traffic typically follows a pattern that may be exploited to improve the overall system performance. For example, the mmRSUs need not be ON all the time; instead, these can be intelligently switched ON/OFF based on the current traffic conditions. We formulated two optimizations to address these - first, to minimize the energy consumption of the mmRSUs, and second, to maximize the system utility. We proposed a heuristic and a Deep Q-Learning-based solution, respectively. The cost-efficient network infrastructure design and mmRSU management are critically important to improve overall system performance. Nevertheless, such solutions are inadequate to support the diverse vehicular applications in real-time. The network infrastructure nodes need to dynamically allocate and manage their resources for service provisioning of the vehicular nodes. Hence, in the final chapter, we examined intelligent resource management in Multi-access Edge Computing (MEC) assisted vehicular networks for offloading prioritized tasks. We formulated a resource optimization problem to maximize the system utility and offered a solution based on the Deep Reinforcement Learning technique.

Keywords: Vehicular Networks, Improved Service Provisioning, Routing, Message Dissemination, Network Infrastructure Design, Intelligent Resource Management.