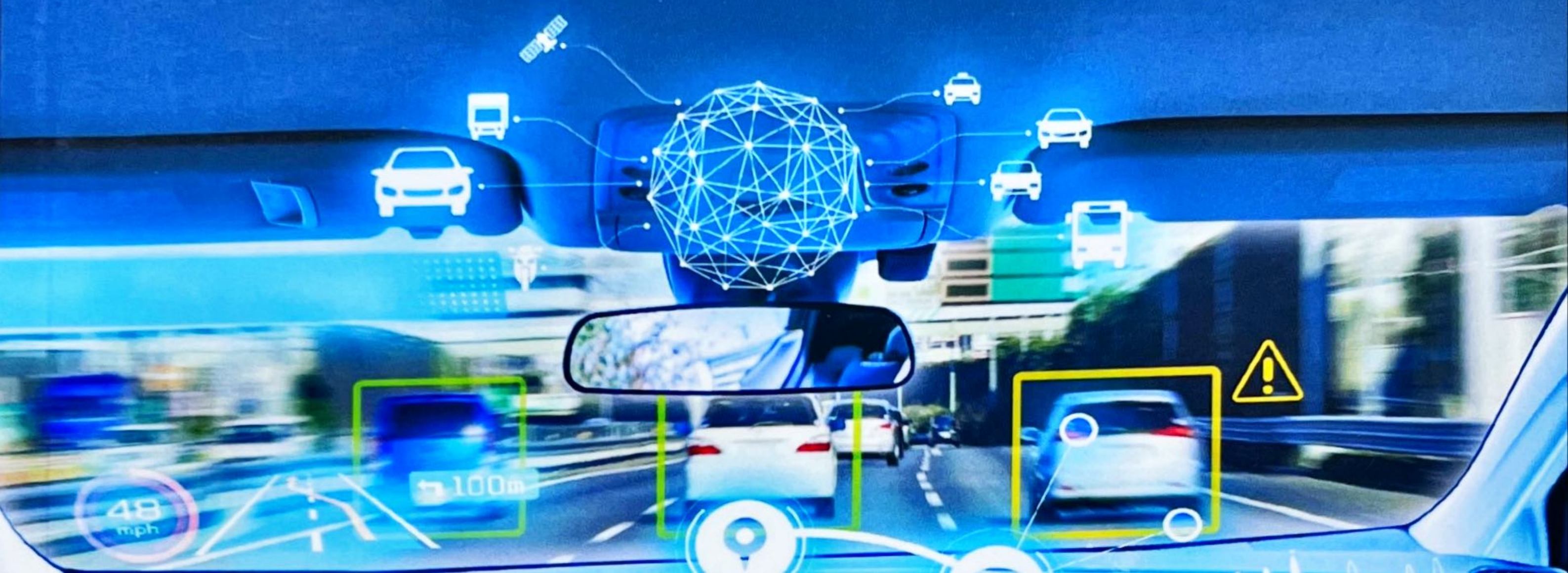
Vehicle-to-Vehicle and Vehicle-to-Infrastructure Communications

A Technical Approach



Vehicle-to-Vehicle and Vehicle-to-Infrastructure Communications

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Preface

The concept of a smart city has attracted attention from many countries. Intelligent transportation is the critical component in a smart city. To achieve intelligent transportation, all vehicles must be aware of the local and nearby traffic situations to avoid traffic jams. This requires that a vehicle should keep real-time, continuous communications with nearby vehicles as well as the road traffic base stations that connect to the city infrastructure.

Up to this point there is no book to cover the engineering designs of vehicle-to-vehicle and vehicle-to-infrastructure communications. Those existing books just cover general vehicle communication issues from the city infrastructure or commercial perspectives. This will be the first book to cover the communication hardware and software details as well as system integration models for two important vehicle communication types: vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications. We use V2X to refer to both network types.

The targeted audience includes academic researchers, graduate students, company R&D people, government decision-makers, and other interested readers.

The book is organized as follows:

Section I. Overview: In this part, we summarize the technical challenges of V2X communications, network architectures, protocol stack, and how V2X systems can be used to detect congestion locations and levels.

Section II. V2X Routing: First, we introduce a comprehensive and comparative study in a city environment of representative routing protocols developed for inter-vehicular networks and wireless mobile ad hoc networks. The strengths and weaknesses of these techniques are discussed based on various network scenarios with regard to their support for highly mobile nodes. Second, we present a service architecture that exercises a software-defined network (SDN) concept to enable efficient data services in vehicular networks by exploiting the synergy between V2V and V2I communications. SDN is an emergent paradigm which brings flexibility and programmability to networks.

Section III. V2X Networking Schemes: There are many different network protocols and standards that can be used to achieve V2X communications. Here we select three important network types: (1) Dedicated short-range communication (DSRC): The digital tachograph (DT) is a device installed in commercial vehicles above 3.5 tonnes in Europe to monitor the driving time of commercial drivers. We will analyze the application of DSRC to the DT, discuss the benefits for law enforcers and propose a feasibility study to evaluate the transmission and reception of data from the DT. (2) In-cabin Wi-Fi: Automobile manufacturers are delivering a new generation of connected vehicles with in-cabin Wi-Fi devices, enabling advances in a wide range of in-vehicle communications and infotainment capabilities. We will answer the following question: if every running vehicle is equipped with an in-cabin Wi-Fi, how will the communication performance be affected by the varied number of surrounding vehicles, the transmission power, and the data rate? (3) Vehicle light communications: Considering the wide deployment of light emitting diodes (LEDs) both in automotive lighting and roadside infrastructure, visible light communication (VLC) has emerged as a potential complementary technology for V2X communications.

Section IV: V2X Applications: In this part, we will introduce some interesting applications that are based on a V2X platform. For example, we can build a cyber-physical system for platoon-aware traffic light rescheduling in the smart cities (SC) of tomorrow. It can enhance urban mobility by exploring methods and management strategies that increase system efficiency and improve individual mobility through information sharing, avoid congestion of key transportation corridors through cooperative navigation systems, and handle nonrecurring congestion. As another application, automated vehicle technologies have been implemented in practice progressively for at least a decade in passenger cars and commercial vehicles. A predecessor technology for automated vehicles is cruise control (CC), which regulates the vehicle speed to the driver's desired/selected speed regardless of traffic immediately in front, so the driver needs to adjust the set speed for a proper following distance. CC can utilize V2X for a smooth operation.

Section V: Antennas for V2X: Multiple input multiple output (MIMO) antenna systems offer high data rates (gigabit wireless link) and good quality of service (QoS) in non-line-of-sight (NLOS) environments. The applicability of MIMO techniques in V2V communications is examined in this part. MIMO helps to meet safety requirements and acceptable user experience for infotainment applications. We will show the effect of antenna beam direction, orientation, and position on the MIMO system performance through site-specific numerical simulations. Directive antenna performance is studied and compared with omnidirectional antennas. This part will also expound on (a) the electromagnetic waves as the energy departs the antenna, (b) the antenna patterns, (c) significant characteristics in antenna patterns, (d) common antenna patterns, (e) free space antenna path loss, and (f) the antenna location on a vehicle and a roadside unit. Finally, we introduce V2V channel measurements and modeling, which are important for future V2V system designs.

Section VI. Physical Layer Technologies: We will then move to the lowest network stack—the physical layer of V2X platforms. The combination of high data transfer rates, high performance, and multipath attenuation strength renders orthogonal frequency-division multiplexing (OFDM) ideal for current and future communication applications, allowing a response to high service quality requirements. The system presented in this part is prototyped based on the IEEE 802.11p standard, customized for vehicular ad hoc networks, and the signals are transmitted and received using a bandwidth of 10 MHz. The OFDM transceiver implementation is based on field-programmable gate array (FPGA) technology and the very high speed integrated circuit hardware description language (VHDL). In addition, any different decoding techniques have been tried and tested for their performance under a vehicular noisy channel by computer-based simulations under modulation schemes and transmitted through additive white Gaussian noise (AWGN) and Rayleigh fading channel models.

Section VII. Future Developments: In this part, we will introduce some future technologies that can advance V2X designs. First, we will introduce a simulation methodology that can implement SDN-based vehicle networks. Second, we will explain the concept of World Wide Wheels (WWW). We will explain how XG enables the high throughput of V2X.

Finally, we thank all V2X experts for their excellent work in the chapter writing. Due to the time limitation, this book might have some issues. We have tried to give credit to each cited reference in the chapters. If you see any problems in this book, please let us know. Thank you for reading this V2X book!