Intelligent Transportation Systems

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802.11-based Vehicular Communications

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To Tatheer, Sabika, and Sakina–Faraz
To Kaniz, Oyndrilla, Opala, and Orla–Nazmul
To Milan and Vikram–Shyam

Foreword

Vehicular communication is quickly becoming an interesting and exciting area with a number of technologies competing to find acceptance as more and more practical and advanced development work is witnessed. This book covers the basics of vehicular data exchange and focuses on 802.11 and cellular technologies. The mathematical assessment as well as experimental observations pertinent to 802.11-based vehicular communication has been covered in greater detail.

I recommend this book to professionals and students working in the wider area of information and communications technologies. I highly recommend this book to graduate, doctoral, and postdoctoral researchers working in vehicular communication, particularly in ITS (intelligent transport system) research areas.

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Preface

The European Union directive 2010/40/EU defines the intelligent transport system (ITS) as a system with advanced applications which aims to improve transport management by increasing the coordination and flow of information between on-road vehicles. The application of information and communications technologies (ICT) in the transport sector has a key role in improving efficiency, safety, public security, and management of a transportation system. Keeping in view the contribution made by ICT in realizing many aspects of ITS, this book explores the networks which enable data exchange between vehicles.

There are two candidate technologies that make a strong case for application in vehicular environments. The 802.11 WLANs have traditionally been considered due to the massive deployment of their access points (APs) across most of the cities. IEEE has also based its standard for vehicular communication, the 802.11p WAVE, on the legacy of 802.11 WLAN. The fact that WLANs allow quick commencement of data exchange between vehicles makes them an ideal choice for exchanging time-critical information. On the other hand, the recent advances in cellular technology have also introduced an ad hoc mode where the mobile devices can exchange data largely independent of the network infrastructure. The so-called device-to-device communication has recently attracted attention. However, its use in vehicular environments still requires considerable research and development. Since 802.11 WLAN is a more mature technology, we keep it in our focus in the rest of this book while also exploring the present state of the art of the cellular technology.

This book comprises of nine chapters. Basic concepts pertinent to IEEE 802.11 networks, vehicular communications, and challenges associated with 802.11-based vehicular communications have been discussed in Chap. 1. Chapter 2 provides a detailed review of the previous research done in vehicular communications. More specifically, the works pertinent to disruption-tolerant networking and handover latency have been reviewed. It also introduces some recent IEEE standards that are relevant in vehicular communication. Chapter 3 discusses the measurement results on parameters such as the signal strength and the data rates supported by the indoor APs in vehicular environments. Chapters 4, 5, and 6 focus upon the analytical modeling of the disruption-tolerant vehicular networks. Starting with a two-state

model in Chap. 4, this book presents a more complete Markov model in Chap. 5. Chapter 6 contains the application of the proposed model to quantify the benefits of using inter-operator roaming. Chapter 7 discusses the issues related with handovers in the vehicular context. Latency evaluations are provided at the beginning of the chapter followed by a description of the proposed channel scanning scheme to reduce scanning phase delay.

Chapter 8 outlines the recent advances in cellular technology. The concept of fifth generation (5G) of cellular networks is rapidly gaining momentum and is set to challenge the ad hoc mode of Wi-Fi. The so-called device-to-device (D2D) communication under the wider larger 5G umbrella can provide rapid infrastructure-free data exchange—a feature which makes it a competitor of using WLANs in vehicular environments. The concluding remarks and future works are covered in Chap. 9, while the references and appendices are given at the end of this book.

This book is written for both mature and early-stage researchers including postgraduate and doctoral students. Researchers from other fields interested in vehicular communications can also find this book interesting and informative. The detailed discussion on the prevailing research trends provided here will be useful for postgraduate and postdoctoral researchers. This book would also be helpful as a secondary source for courses related to wireless networking.

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Contents

Abbreviations

3GPP	3rd Generation partnership project
A2M	All to Minimum
ACK	Acknowledge (packet)
AMV	Automatic mobile vehicle
AP	Access Point
ARP	Address resolution protocol
BSS	Basic service set
CEPS	Center for European policy studies
CTP	Cabernet transfer protocol
DHCP	Dynamic host configuration protocol
DSL	Digital subscriber line
DSRC	Dedicated short-range communication
DSSS	Direct sequence spread spectrum
DTN	Disruption-tolerant networking
EAP	Extensible authentication protocol
EAPOL	EAP over LAN
EDGE	Enhanced data rates for GSM evolution
ESS	Extended service set
FT	Fast transition
GPRS	General packet radio service
GSM	Global system for mobile communication
HAPS	History-based AP selection
HMAC	Hash message authentication code
HMM	Hidden Markov model
HSDPA	High-speed downlink packet access
HT	High throughput
IANA	Internet assigned numbers authority
ICMP	Internet control message protocol
ICT	Information and communications technology
IEEE	Institute of electrical and electronics engineers
IP	Internet protocol

IPN	IP network
ISM	Industrial, scientific, and medical (band)
ISP	Internet service provider
LoS	Line of sight
LTER	Long-term error rate
MAC	Medium access control
MANET	Mobile Ad hoc Network
MAR	Mobile access router
MIMO	Multiple input, multiple output
MN	Mobile node
MRP	Markov renewal process
MULE	Mobile ubiquitous LAN extensions
NAK	Negative ACK
NIC	Network interface card
OBU	On-board unit
OFDM	Orthogonal frequency division multiplexing
OSA	Open system authentication
PEAP	Protected EAP
PEN	Private enterprise number
PHY	Physical (layer)
PKI	Public key infrastructure
PL	Packet loss
PMK	Pairwise master key
PRMA	Packet reservation multiple access
PTK	Pairwise transient key
QoS	Quality of service
R2V	Roadside to vehicle
RADIUS	Remote authentication dial-in user service
RSS	Received signal strength
RSU	Roadside unit
RTT	Round trip time
SAPS	Scan-based AP selection
SKA	Shared key authentication
SNR	Signal-to-noise ratio
SOHO	Small office/home office
SSL	Secured socket layer
TCP	Transmission control protocol
UMTS	Universal mobile telecommunications system
V2V	Vehicle to vehicle
VAC	Vehicular address configuration
VANET	Vehicular Ad hoc Network
VoIP	Voice over internet protocol
WAVE	Wireless access in vehicular environments
WEP	Wired equivalent Privacy
WHO	World health organization

WiMAX	Worldwide interoperability for microwave access
WISPr	Wireless ISP roaming
WLAN	Wireless local area network
WNIC	Wireless network identity card
WSN	Wireless sensor network

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