Intelligent Transport Systems

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802.11-based Roadside-to-Vehicle Communications

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To Prof. S. M. Iqbal and Mrs. Yasmeen Iqbal, and Nida, Khadeeja and Waqar

—Faraz

To Kaniz, Oyndrilla, Opala, and Orla

—Nazmul

To Titia, Gupi and Joanna

—Shyam

Foreword

This book is concerned with 802.11-based wireless networks and their use in emerging vehicular mobility domains. The book is generally concerned with information exchange between vehicles and 802.11-based roadside infrastructure, and lays particular focus on two key research directions: mathematical modeling and handover latency in vehicular communication. The major contributions of this book are focused on the mathematical modeling of vehicular communications—an important and relatively less investigated research area. Since the models developed are based on experimental data, they are capable of portraying real picture of 802.11-based R2V communications. Moreover, the issue of large handover latency has been addressed. This is one of the main hindrances in the widespread use of WLANs from vehicles. In addition to delineating a comprehensive delay analysis of handover, this book introduces a scheme to reduce the delay in the scanning phase of handovers. I sincerely hope that the book will be helpful for graduate, doctoral, and post doctoral researchers.

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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, without embodying intelligence as such, aims to improve transport management by increasing coordination and flow of information between on-road vehicles. It has also been envisaged that the application of information and communication technologies (ICT) in the transport sector has a key role in improving efficiency, safety, public security, and freight mobility management of a transportation system. Keeping in view the contribution made by ICT in realizing ITS, the authors have explored the communication mechanism between vehicles to enable various infotainment services.

This book is a result of 3 years of doctoral research focusing on one important aspect of Intelligent Transportation System: the roadside to vehicle (R2V) communications. This research work specifically explores the use of IEEE 802.11 technologies in the R2V scenario. The outcome of this research is also highly relevant in those situations where roadside 802.11 APs are specifically deployed for R2V communications.

Ever since their introduction in the late 1990s, WLAN APs have seen massive deployment across most modern cities. The idea of using already available indoor APs in outdoor vehicular environments has recently come under scrutiny. Although WLAN APs exist in large numbers alongside roads in most developed cities, the placement of these APs is highly unplanned. These WLAN APs cannot support continuous connectivity over a large mobility domain due to their unplanned deployment. Consequently, the network services offered by WLANs are disrupted when used in vehicular environments. While various research works are focused on disruption tolerant networking, this book develops and explores a completely new research direction—developing stochastic models of disruption in 802.11 WLANs and their implications on the vehicular communication systems. Second, a vehicle spends very little time within the AP footprint, most of which is consumed in handing over to the AP. Because of the small outdoor coverage region of the AP and the high speed of the vehicle, handovers inevitably occur frequently. The delay in handing over to these APs is termed as handover latency.

In order to achieve smoother transitions between the APs, the handover latency must be reduced. This book analyzes the latency by measuring various delays incurred during handovers.

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 both doctoral and post doctoral researchers. This book would also be helpful in courses related to wireless networking since it covers the application of stochastic tools in analyzing communication networks in considerable detail.

The book comprises eight chapters. The 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 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. A scheme for monitoring traffic congestion using the existing WLAN infrastructure has also been presented in this chapter.

Chapters 4–6 focus upon the analytical modeling of the disruption tolerant vehicular networks. Chapter 4 provides a 2-state and, next, a 3-state Markov model to compute the long-term error rate as a means of representing disruption. Chapter 5 modifies this model to hidden Markov model and introduces the probabilistic measures of disruption. 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. The concluding remarks and future works are supplied in Chap. 8 while references and appendices are given at the end of this book.

Acknowledgments

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Contents

Abbreviations

3GPP	3rd Generation Partnership Project
AP	Access point
A2M	All to minimum
ACK	Acknowledge (packet)
AMPS	Advanced Mobile Phone Services
AMV	Automatic mobile vehicle
ARP	Address resolution protocol
BSS	Basic service set
CDMA	Code Division Multiple Access
CEPS	Center for European Policy Studies
CTP	Cabernet transfer protocol
DHCP	Dynamic host configuration protocol
DSL	Digital subscriber line
DSRC	Direct 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
GSM	Global system for mobile communication
GPRS	General packet radio service
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 number agency
ICMP	Internet control messaging protocol
ICT	Information and communication technology

IEEE	Institute of Electrical and Electronic Engineers
IP	Internet protocol
IPN	IP network
ISM	Industrial, scientific, medical (band)
ISP	Internet service provider
ITS	Intelligent Transportation Systems
LAN	Local Area Network
LoS	Line of sight
LTER	Long term error rate
MAC	Medium access control
MANE	Mobile Adhoc 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
NMT	Nordic Mobile Telephone
OBU	On board unit
OFDM	Orthogonal frequency division multiplexing
OSA	Open systems 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
SSID	Service Set Identifier
SSL	Secured socket layer
TCP	Transmission control protocol
UMTS	Universal mobile telecommunication system
V2V	Vehicle-to-vehicle

VAC	Vehicular address configuration
VANET	Vehicular Adhoc NETwork
VoIP	Voice over internet protocol
WAVE	Wireless access in vehicular environments
WBSS	WAVE BSS
WEP	Wired equivalent protocol
WHO	World Health Organization
WiMAX	Wireless Interoperability for Microwave Access
WISPr	Wireless ISP roaming
WLAN	Wireless local area network
WNIC	Wireless network identity card
WSN	Wireless sensor Network