Wireless Networks

Yuanguo Bi
Haibo Zhou
Weihua Zhuang
Hai Zhao

Safety Message Broadcast in Vehicular Networks

Springer

Wireless Networks

Series editor

Xuemin (Sherman) Shen
University of Waterloo, Waterloo, Ontario, Canada

More information about this series at http://www.springer.com/series/14180

Yuanguo Bi · Haibo Zhou · Weihua Zhuang
Hai Zhao

Safety Message Broadcast in Vehicular Networks

Springer

Yuanguo Bi
School of Computer Science and Engineering
Northeastern University
Shenyang
China

Haibo Zhou
Department of Electrical and Computer Engineering
University of Waterloo
Waterloo, ON
Canada

Weihua Zhuang
Department of Electrical and Computer Engineering
University of Waterloo
Waterloo, ON
Canada

Hai Zhao
School of Computer Science and Engineering
Northeastern University
Shenyang
China

ISSN 2366-1186 ISSN 2366-1445 (electronic)
Wireless Networks
ISBN 978-3-319-47351-2 ISBN 978-3-319-47352-9 (eBook)
DOI 10.1007/978-3-319-47352-9

Library of Congress Control Number: 2016959183

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Remarkable advance of wireless communications and extensive use of mobile electronics have made vehicular networks no longer a futuristic promise, but rather an attainable technology to enable moving vehicles to quickly and accurately collect real-time road traffic information. Such kind of information can be utilized to notify vehicles of potential dangerous events, which meets the imminent demands towards reduced traffic accidents and improved road efficiency in intelligent transportation system (ITS). However, information transmissions in the hostile vehicular environment are fraught with fundamental challenges such as message redundancy, link unreliability, hidden terminal, and so on. These challenging issues may greatly degrade the performance of safety-related applications that have strict quality of service (QoS) requirements such as low latency, high reliability, and scalability.

Broadcast is a frequently used technique to advertise information in traditional ad hoc networks, and recently has been considered as a promising solution to disseminate safety-related information for cooperative driving in vehicular networks. However, designing an efficient broadcast protocol in the vehicular environment requires thorough investigations to address the associated challenges. The aim of this book is to investigate safety message disseminations and present recent research results on single-hop and multi-hop broadcast protocol design and modeling in vehicular networks. An overview of vehicular networks is first presented, followed by a detailed discussion of challenges in safety message disseminations. Then, a comprehensive survey of current state-of-the-art research literature on message broadcasting is conducted. In order to address some challenging issues (e.g., redundancy, link unreliability, hidden terminal, and broadcast storm) in safety message broadcast and to meet the QoS requirements (e.g., low latency, high reliability, scalability) of safety applications, a distributed multi-hop broadcast protocol is proposed to forward safety messages in the desired propagation direction. Then, an urban multi-hop broadcast protocol including directional broadcast, bi-directional broadcast, and multi-directional broadcast is presented to adapt to the more complex urban road layout in distributed vehicular networks. Furthermore, a busy tone based MAC scheme is presented to provide strict priority to safety messages by channel

preemption in infrastructure-based vehicular networks. Finally, we summarize the book and outline some open issues for further research in this direction.

We would like to thank Prof. Lin Cai from Illinois Institute of Technology, Prof. Hangguan Shan from Zhejiang University, and Prof. Hao (Tom) Luan from Deakin University, for their contributions in the research works. We also would like to thank the members of BBCR from University of Waterloo for their valuable discussions and suggestions. Special thanks to the staff at Springer Science+Business Media: Susan Lagerstrom-Fife and Jennifer Malat, for their effort and support throughout the publication preparation process.

Shenyang, China — Yuanguo Bi
Waterloo, Canada — Haibo Zhou
Waterloo, Canada — Weihua Zhuang
Shenyang, China — Hai Zhao

Contents

Acronyms

ABF	Adaptive Broadcast Frame
ABS	Anti-lock Brake System
AC	Access Category
ACK	ACKnowledgement
AHP	Analytical Hierarchy Process
AIFS	Arbitration Inter-Frame Space
AMB	Ad hoc Multi-hop Broadcast
AP	Access Point
AWGN	Additive White Gaussian Noise
BCTS	Broadcast Clear-To-Send
BCUnit	Broadcast Control Unit
BER	Bit Error Rate
BIFS	Broadcast Inter-Frame Space
BMW	Broadcast Medium Window
BPAB	Binary-Partition-Assisted Broadcast
BRTS	Broadcast Request To Send
BS	Base Station
BSS	Basic Service Set
CFP	Contention Free Period
CH	Cluster Head
CLBP	Cross Layer Broadcast Protocol
CP	Contention Period
CRP	Contention based Reservation Period
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
CS-TDMA	CSMA and Self-organizing TDMA
CTB	Clear-To-Broadcast
CTS	Clear-To-Send
CW	Contention Window
DADCQ	Distribution Adaptive Distance with Channel Quality
DBA-MAC	Dynamic Backbone Assisted-MAC

D-CBM	Dual Cluster Based MAC
DIFS	Distributed Inter-Frame Space
DMAC	Directional MAC
DSAB	Dynamic Search-Assisted Broadcast
DSRC	Dedicated Short Range Communication
EDCA	Enhanced Distributed Channel Access
FA	Far Area
FCC	Federal Communications Commission
FCFS	First Come First Serve
GDP	Gross Domestic Product
GPS	Global Positioning System
GW	GateWay
HCCA	Hybrid coordination function Controlled Channel Access
ITS	Intelligent Transportation System
LTE	Long-Term Evolution
MAC	Medium Access Control
MRB	Multi-behavior and Reliable Broadcast
NA	Near Area
OBU	On-Board Unit
OFDMA	Orthogonal Frequency Division Multiplexing Access
PATH	Partners for Advanced Transit and Highway
PC	Point Coordinator
PER	Packet Error Rate
PMB	Position-based Multi-hop Broadcast
PMF	Probability Mass Function
QoS	Quality of Service
RDAB	Relative Degree Adaptive flooding Broadcast
RSU	Road-Side Unit
RTB	Request-to-Broadcast
RTS	Request-to-Send
SDMA	Space Division Multiple Access
SDN	Software Defined Networking
SIFS	Short Inter-Frame Space
SOFTMAC	Space-Orthogonal Frequency-Time Medium Access Control
TDMA	Time Division Multiple Access
UMB	Urban Multi-hop Broadcast
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VANET	Vehicular Ad hoc NETwork
VeMAC	Vehicular ad hoc network Medium Access Control
WAVE	Wireless Access in Vehicular Environment
WSMP	WAVE Short Message Protocol
WHO	World Health Organization