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Haixia Peng • Qiang Ye • Xuemin Sherman Shen

Intelligent Resource Management in Vehicular Networks

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Haixia Peng
Department of Computer Engineering & Computer Science
California State University Long Beach
Long Beach, CA, USA

Qiang Ye
Department of Computer Science
Memorial University of Newfoundland
St. John's, NL, Canada

Xuemin Sherman Shen
Department of Electrical & Computer Engineering
University of Waterloo
Waterloo, ON, Canada

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Preface

Connected and automated vehicle technology has been emerging and is expected to intelligentize future transportation systems due to the technological innovation of wireless communication and the automobile industry. By allowing real-time information exchange between vehicles and everything, traffic safety and efficiency can be improved, and ubiquitous Internet access can be enabled to support new transportation applications. However, with increase in types of service as well as the number of vehicles, additional mobile data traffic and sensing tasks are generated by vehicles, which overwhelm the communication and computation capacities on individual vehicles. On the other hand, due to the limitation of radio spectrum and vehicle's on-board computing and storage resources, promoting vehicular networking technologies to support the emerging vehicular applications is challenging, especially those requiring sensitive delay and diverse resources. To address these challenges, new vehicular networking architectures and efficient resource management schemes are presented in this book to accommodate the emerging applications and services with different levels of quality-of-service (QoS) guarantee. This book includes six chapters:

In Chap. 1, we give an introduction to vehicular networks, including applications, characteristics, classifications, available communication technologies, and challenges in communication and computing, and then the resource management in vehicular networks is introduced from the perspectives of different dimensions of resources.

In Chap. 2, we design a new vehicular network architecture, which combines multi-access edge computing (MEC), software-defined networking, network function virtualization, and artificial intelligence technologies to support the emerging vehicular applications.

In Chap. 3, we study the spectrum resource management problems for MEC-based vehicular networks (MVNETs) to improve spectrum resource utilization while guaranteeing QoS requirements for different applications. Specifically, the spectrum slicing, spectrum allocation, and transmit power control are jointly investigated.

In Chap. 4, we jointly investigate the spectrum, computing, and caching resource allocation problem in MVNETs. To achieve real-time resource allocation among different vehicular applications intelligently, multi-dimensional resource optimization problems are studied and solved by reinforcement learning under two typical MVNET architectures.

In Chap. 5, we extend the proposed MVNET architecture to an unmanned aerial vehicle-assisted MVNET and investigate the multi-dimensional resource management problem. To efficiently provide on-demand resource access to vehicle users, the resource allocation problem is formulated as optimization problems, which are then solved using both single-agent and multi-agent deep deterministic policy gradient methods.

In Chap. 6, we conclude this book and discuss future research issues in vehicular networks.

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Long Beach, CA, USA — Haixia Peng
St. John's, NL, Canada — Qiang Ye
Waterloo, ON, Canada — Xuemin (Sherman) Shen

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Acronyms

3GPP	3rd Generation Partnership Project
5G	5th Generation
ACS	Alternate Concave Search
ADS	Automated Driving System
ADVNETs	Automated Driving Vehicular Networks
AI	Artificial Intelligence
APs	Access Points
AUs	Application Units
AVs	Autonomous Vehicles
AWGN	Additive White Gaussian Noise
BBUs	BaseBand Units
BSs	Base Stations
CAVs	Connected and/or Autonomous Vehicles
CCH	Control Channel
CR	Cognitive Radio
D2D	Device-to-Device
DDPG	Deep Deterministic Policy Gradient
DDT	Dynamic Driving Task
DMIPS	Dhrystone Million Instructions Executed per Second
DNN	Deep Neural Network
DPG	Deterministic Policy Gradient
DQN	Deep Q-Network
DRL	Deep RL
DSRC	Dedicated Short Range Communications
EN	Edge Node
eNBs	evolved NodeBs
FCC	Federal Communications Commission
FCW	Forward Collision Warning
HD	High Definition
HDDPG	Hierarchical DDPG
HDVNETs	Heterogeneous Driving Vehicular Networks

I2I	Infrastructure-to-Infrastructure
ITS	Intelligent Transportation System
LTE	Long-Term Evolution
MADDPG	Multi-Agent DDPG
MANETs	Mobile Ad Hoc Networks
max-SINR	maximization-SINR
max-utility	maximization-utility
MBS	Macro-cell BS
MDPs	Markov Decision Processes
MDVNETs	Manual Driving Vehicular Networks
MEC	Multi-access Edge Computing
MeNB	Macro eNB
MIMO	Multiple-Input-Multiple-Output
MINLP	Mixed-Integer Nonlinear Programming
mmWave	millimeter-wave
MP-DQN	Multi-Pass Deep Q-Network
MVNETs	MEC-assisted Vehicular Networks
NFV	Network Function Virtualization
NOMA	Non-Orthogonal Multiple Access
OBU	On-Board Unit
ODD	Operational Design Domain
OEDR	Object and Event Detection and Response
OFDM	Orthogonal Frequency-Division Multiplexing
P-DQN	Parametrized Deep Q-Network
QoS	Quality of Service
RAN	Radio Access Network
RL	Reinforcement Learning
RRHs	Remote Radio Heads
RRM	Radio Resource Management
RSUs	Road Side Units
SAC	Soft Actor-Critic
SADDPG	Single-Agent DDPG
SAE	Society of Automotive Engineers
SCHs	Service Channels
SDN	Software Defined Networking
SINR	Signal to Interference plus Noise Ratio
UAV	Unmanned Aerial Vehicle
UHF	Ultra High Frequency
V2C	Vehicle-to-Cloud
V2I	Vehicle-to-Infrastructure
V2P	Vehicle-to-Person
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VHF	Very High Frequency
VLC	Visible Light Communication

VMs	Virtual Machines
VNFs	Virtual Network Functions
VR	Virtual Reality
WLANs	Wireless Local Area Networks