

# SpringerBriefs in Electrical and Computer Engineering

## Series editors

Woon-Seng Gan, School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore, Singapore

C.-C. Jay Kuo, University of Southern California, Los Angeles, CA, USA

Thomas Fang Zheng, Research Institute of Information Technology, Tsinghua University, Beijing, China

Mauro Barni, Department of Information Engineering and Mathematics, University of Siena, Siena, Italy



SpringerBriefs present concise summaries of cutting-edge research and practical applications across a wide spectrum of fields. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic. Typical topics might include: timely report of state-of-the art analytical techniques, a bridge between new research results, as published in journal articles, and a contextual literature review, a snapshot of a hot or emerging topic, an in-depth case study or clinical example and a presentation of core concepts that students must understand in order to make independent contributions.

More information about this series at <http://www.springer.com/series/10059>



Waleed Ejaz • Alagan Anpalagan

# Internet of Things for Smart Cities

Technologies, Big Data and Security



 Springer

Waleed Ejaz  
Thompson Rivers University  
Kamloops, BC, Canada

Alagan Anpalagan  
Ryerson University  
Toronto, ON, Canada

ISSN 2191-8112 ISSN 2191-8120 (electronic)  
SpringerBriefs in Electrical and Computer Engineering  
ISBN 978-3-319-95036-5 ISBN 978-3-319-95037-2 (eBook)  
<https://doi.org/10.1007/978-3-319-95037-2>

Library of Congress Control Number: 2018954057

© The Author(s), under exclusive licence to Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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

*This book is dedicated to our families.*



# Foreword

Internet of Things (IoT) has now become a key enabling technology that spans multiple technology domains from data sensing and processing to networking and data analytics. IoT is used in many applications ranging from home security and factory automation to healthcare delivery to autonomous driving. In this book, the authors provide an essential overview of IoT for smart cities and key challenges associated with it, then cover communication technologies and protocols for IoT in smart cities. The coverage includes big data impacts on IoT operations, in terms of processing, storage, and analytics; security and privacy issues; and challenges of IoT for smart cities. IoT-based charging solution for electric vehicles is demonstrated as a practical application in smart cities. As such, it will be a good reference resource for graduate students, researchers, and industry practitioners working in IoT applications for smart city.

University of Idaho  
Moscow, ID, USA  
September 2018

Prof. Mohsen Guizani  
Ph.D., FIEEE

# Preface

The concept of the smart city was introduced as the potential solution to the challenges created by urbanization with complex and costly operations. The envisioned goal of smart city is to be cost effective, intelligent, and autonomous with ease-of-use providing better quality of life. Most definitions for smart city involve the use of information and communication technologies (ICTs) to enhance the quality of urban life with reduced cost and resource consumption. Recently, ICT convergence with the Internet of Things (IoT) has been effectively exploited to provide many novel features with minimum human intervention in smart cities. This book describes different components of IoT for smart cities including sensor technologies, communication technologies, big data analytics, and security. The book is organized into five chapters that are described below.

IoT offers smart solutions for cities in terms of governance, economic growth, environmental sustainability, quality of life, transportation, power, and water usage. In Chap. 1, the authors provide an insight into different aspects of smart cities, challenges, and common IoT solutions for future cities.

In Chap. 2, the authors provide an overview of the general classification of communication protocols for IoT networks followed by the analysis of the technical details and specific advantages and limitations of different protocol. Recent protocols for IoT networks are discussed with the comparative analysis of two use cases of IoT and the communication technologies.

Chapter 3, titled Dimension Reduction for Big Data Analytics in Internet of Things, presents an overview of dimension reduction in IoT systems. A discussion on solutions for dimension reduction with focus on principal component analysis is also presented to reduce consumption of energy and computation resources.

The Internet of Vehicles paradigm can play a significant role by providing holistic data exchange between charging infrastructure and electric vehicles (EVs) in emerging smart cities. Large-scale implementation of EVs can impose extra burdens on electric grids making the scheduling essential to optimize the charging process. The authors of Chap. 4 present a profit maximization approach for EV charge scheduling in smart distribution systems by considering the cost and speed of charging at the charging stations.

Recently, blockchain technology is investigated extensively for security and privacy in IoT. Chapter 5 provides an overview of the use of blockchain technology for IoT. First, the authors review the literature for a better understanding of research direction in blockchain for IoT systems. The challenges associated with the deployment of IoT and blockchain for the IoT systems are discussed followed by two case studies on smart homes and food supply chain traceability to show the effectiveness of blockchain technology for IoT.

Kamloops, BC, Canada  
Toronto, ON, Canada  
September 2018

Waleed Ejaz  
Alagan Anpalagan





# Acknowledgments

We are very thankful to several people who have worked hard to bring forward this unique resource for helping students, researchers, and practitioners. Our students have contributed in part to the writing of the chapters: D. Vong (Chap. 1), S. S. Sahoo (Chap. 2), M. Basharat (Chaps. 3 and 5), and M. Umer, M. Naeem, and A. Alnoman (Chap. 4).

We would also like to thank Divyaa Veluswamy and Brinda Megasyamalan, Project Coordinators at Springer, who worked with us on the project from the beginning to the successful end. Finally, we would like to thank our respective families for their continuous support and encouragement during the course of this project.

# Contents

<b>1 Internet of Things for Smart Cities: Overview and Key Challenges</b> .....	1
1.1 Introduction .....	1
1.2 Characteristics of Smart Cities .....	2
1.2.1 Smart Economy .....	3
1.2.2 Smart People .....	4
1.2.3 Smart Governance .....	4
1.2.4 Smart Mobility .....	4
1.2.5 Smart Environment .....	4
1.2.6 Smart Living .....	5
1.3 IoT-Based Solutions for Smart Cities .....	5
1.3.1 Smart Grid .....	6
1.3.2 Smart Home .....	8
1.3.3 Transport and Traffic Management .....	9
1.3.4 Smart Healthcare .....	11
1.4 Challenges Ahead .....	11
1.4.1 Planning .....	11
1.4.2 Costs and Quality .....	14
1.4.3 Security and Privacy .....	14
1.4.4 Risks .....	15
1.5 Conclusion .....	15
<b>2 Communication Technologies and Protocols for Internet of Things</b> .....	17
2.1 Introduction .....	17
2.2 Communication Technologies for IoT Networks .....	19
2.2.1 Non-Cellular Communication Technologies .....	19
2.2.2 Cellular Communication Technologies .....	22
2.3 Recent Protocols for IoT .....	23
2.3.1 PHY and MAC Layers .....	23

2.3.2	Network Layer .....	25
2.3.3	Application Layer .....	26
2.4	Study of Communication Technologies Through Use-Case Analysis .....	27
2.4.1	Use Case 1: Intelligent Traffic System (ITS) .....	27
2.4.2	Use Case 2: Disaster Management .....	28
2.5	Conclusion .....	29
<b>3</b>	<b>Dimension Reduction for Big Data Analytics in Internet of Things .....</b>	<b>31</b>
3.1	Introduction .....	31
3.2	Related Work .....	32
3.3	Solutions for Dimension Reduction in IoT .....	33
3.3.1	Principal Component Analysis (PCA) .....	36
3.4	Conclusion and Future Work .....	37
<b>4</b>	<b>Internet of Things Enabled Electric Vehicles in Smart Cities .....</b>	<b>39</b>
4.1	Introduction .....	39
4.2	EV Charge Scheduling and Charging Techniques .....	41
4.3	Renewable Energy for EV Charging .....	42
4.4	Smart Distribution Systems .....	43
4.4.1	Smart EV Scheduling: A Case Study .....	43
4.5	Conclusion .....	46
<b>5</b>	<b>Blockchain Technology for Security and Privacy in Internet of Things .....</b>	<b>47</b>
5.1	Introduction .....	47
5.2	Literature Review .....	49
5.3	Challenges Associated with Secure IoT Deployment and Blockchain for IoT .....	50
5.4	Case Studies .....	53
5.4.1	Smart Homes .....	53
5.4.2	Food Supply Chain Traceability System .....	54
5.5	Conclusion .....	55
	<b>References .....</b>	<b>57</b>
	<b>Index .....</b>	<b>63</b>

# Acronyms

3GPP	Third generation partnership project
3G	Third generation of cellular networks
4G	Fourth generation of cellular networks
5G	Fifth generation of cellular networks
AMQP	Advanced message queuing protocol
BEV	Battery electric vehicle
BLE	Bluetooth low energy
CALM	Continuous air interference long and medium range
CAM	Cooperative awareness message
CoAP	Constrained application protocol
DDS	Data distribution service
DENM	Decentralized environmental notification message
DSRC	Dedicated short range communication
ETSI	European Telecommunications Standards Institute
EV	Electric vehicle
G2V	Grid-to-vehicle
GHG	Greenhouse gas
GNSS	Global navigation satellite system
GPRS	General packet radio service
GPS	Global positioning system
GSM	Global system for mobile communication
H2V	Home-to-vehicle
HACCP	Hazard analysis and critical control points
HEV	Hybrid electric vehicle
ICE	Internal combustion engine
ICTs	Information and communication technologies
IETF	Internet engineering task force
IoST	Internet of Smart Things
IoT	Internet of Things
IoV	Internet of vehicles
ITS	Intelligent transportation system

ITU	International Telecommunication Union
LAN	Local area network
LPWA	Low power wide area
LR-WPAN	Low-rate wireless personal area network
LTE	Long-Term Evolution
MQTT	Message queuing telemetry transport
PCA	Principal component analysis
PET	Plug-in electric train
PEV	Plug-in electric vehicle
PHEV	Plug-in hybrid electric vehicle
PLC	Power line communication
RFID	Radio frequency identification
RPL	Routing protocol for low-power and lossy networks
SIG	Special interest group
SV	Sensor vehicle
UDP	User datagram protocol
V2G	Vehicle-to-grid
V2H	Vehicle-to-home
V2I	Vehicle-to-infrastructure
V2V	Vehicle-to-vehicle

