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Connectivity and Edge Computing in IoT: Customized Designs and AI-based Solutions

Springer

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ISSN 2366-1186 ISSN 2366-1445 (electronic)
Wireless Networks
ISBN 978-3-030-88742-1 ISBN 978-3-030-88743-8 (eBook)
https://doi.org/10.1007/978-3-030-88743-8

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

Preface

The Internet of Things (IoT) is revolutionizing the world and impacting the daily lives of billions of people. Supporting use cases for households, manufacturers, transportation, agriculture, healthcare, and much more, IoT carries many potentials and expectations for prospering human society. Technologically, we are at an early stage of IoT development, aiming at connecting tens of billions of devices to make homes, communities, factories, farms, and everywhere else smart and automated. Tremendous efforts are necessary to advance IoT research and development.

Two cornerstones of IoT are data collection/exchange and data analysis. The former demands connectivity solutions, while the latter requires computing solutions. Due to the broad scope of IoT and the drastically different characteristics and requirements of IoT use cases, no "one-size-fits-all" design can meet the expectations of all use cases. Therefore, customizing connectivity or computing solutions for specific use cases is challenging yet essential. There are many system features and performance measures to consider in the customization, such as connection link density, resource overhead, transmission and computation delay, service reliability, energy efficiency, and device mobility, and making proper trade-offs among them is critical.

Accounting for all performance metrics and making optimal trade-offs can yield high complexity. Correspondingly, artificial intelligence (AI) solutions, such as neural networks and reinforcement learning, can become useful. Powered by AI methods, connectivity or computing solutions can learn from experience to handle the complexity, assuming that sufficient data are available for training. Specifically, AI can play various roles in IoT, including data traffic load prediction, access control, and computation task scheduling, to name a few.

In this book, we focus on connectivity and edge computing in IoT and present our designs for four representative IoT use cases, i.e., smart factory, rural IoT, Internet of vehicles, and mobile virtual reality. We thoroughly review the existing research in this field, including many works published in recent years. Then, through innovative designs, we demonstrate the necessity and potential of customizing solutions based on the use cases. In addition, we exploit AI methods to empower our solutions. The four research works included in this book serve a collective objective:

enabling on-demand data collection and/or analysis for IoT use cases, especially in resource-limited IoT systems. We hope that this book will inspire further research on connectivity and edge computing in the field of IoT.

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July 2021

Acknowledgements

The authors would like to thank Professor Xuemin (Sherman) Shen at the University of Waterloo, the Editor of the *Wireless Networks* series, for his support in publishing this book and his comments and suggestions on its technical content.

We would also like to thank Professor Lian Zhao at the Ryerson University for her helpful discussions on the research presented in Chaps. 3 and 4.

In addition, we thank Dr. Xu Li, Professor Nan Cheng, and Conghao Zhou, who participated in the research discussed in Chaps. 2, 4, and 5, respectively.

We appreciate valuable discussions with the members of the Broadband Communications Research (BBCR) Lab at the University of Waterloo.

Special thanks to Susan Lagerstrom-Fife, Senior Editor at Springer New York, and Shina Harshavardhan, Project Coordinator for Springer Nature for their help during the preparation of this monograph.

Contents

Acronyms

3GPP	Third generation partnership project
5G	Fifth generation
5G NR	5G new radio
AC	Actor-critic
AD	Access delay
AD-F	Access delay counted in frames
ADMM	Alternating direction method of multipliers
AI	Artificial intelligence
AP	Access point
BFoV	Base field-of-view
BS	Base station
CNN	Convolutional neural network
CSMA	Carrier-sense multiple access
DCF	Distributed coordination function
DDPG	Deep deterministic policy gradient
DNN	Deep neural network
DQN	Deep Q network
DRL	Deep reinforcement learning
EDT	Early data transmission
EFoV	Extended field-of-view
eMBB	Enhanced mobile broadband
ET	Enhanced tile
FoV	Field-of-view
HMD	Head-mounted device
HP	High priority
IIoT	Industrial Internet of Things
IoT	Internet of Things
IoV	Internet of Vehicles
IT	Information technology
LoRa	Long range
LP	Low priority

LPWA	Low-power wide-area
LSTM	Long short-term memory
LTE	Long-term evolution
LTE-M	Long-term evolution for machine-type communications
M2M	Machine-to-machine
MAC	Medium access control
MDP	Markov decision process
mMTC	Massive machine-type communications
mmWave	Millimeter-wave
MsCS	Mini-slot based carrier sensing
MSE	Mean squared error
MTC	Machine-type communication
NB-IoT	Narrowband IoT
NOMA	Non-orthogonal multiple access
QoE	Quality of experience
QoS	Quality of service
RACH	Random access channel
RAW	Restricted access window
RMAB	Restless multi-armed bandit
RP	Regular priority
RSU	Roadside unit
SCA	Successive convex approximation
SOC	Second order cone
SMsA	Superimposed mini-slot assignment
SyncCS	Synchronization carrier sensing
TDMA	Time-division multiple access
TPSA	Task partition and scheduling algorithm
TTI	Transmission time interval
UAV	Unmanned aerial vehicle
URLLC	Ultra-reliable low-latency communications
V2I	Vehicle-to-infrastructure
V2X	Vehicle-to-everything
VR	Virtual reality
VS	Video segment
WI	Whittle index
WLAN	Wireless local area network