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Tho Le-Ngoc • Atoosa Dalili Shoaei

Learning-Based Reconfigurable Multiple Access Schemes for Virtualized MTC Networks

Springer

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ISSN 2366-1186 ISSN 2366-1445 (electronic)
Wireless Networks
ISBN 978-3-030-60381-6 ISBN 978-3-030-60382-3 (eBook)
https://doi.org/10.1007/978-3-030-60382-3

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Preface

Machine-type communications are expected to account for the dominant share of the traffic in future wireless networks. While in traditional wireless networks, designed for human-type communications, the focus is on support of large packet sizes in downlink, machine-type communication systems deal with heavy uplink traffic. This is due to the nature of the tasks performed by machine-type communication devices, which is mainly reporting measured data or a detected event. Furthermore, in these networks, using the virtualization framework, the network infrastructure can be shared between different applications for which providing isolation is of high importance. To support these unique characteristics of machine-type communications, proper access schemes need to be developed, which is the focus of this book.

Leveraging traffic characteristics of the devices can improve the performance of resource utilization of machine-type networks. Therefore, first, we present a traffic-aware carrier sense multiple access (CSMA) scheme with deterministic backoff values, in which the access point assigns backoff values to devices by modeling the problem as a Markov decision process. Furthermore, aiming to improve the performance of the networks, consisting of heterogeneous devices in terms of packet arrival probabilities (i.e., including both frequent and sporadic), we propose a reconfigurable access scheme. In the proposed scheme, time is divided into frames, and each frame is split into two segments: an assignment-based segment and a random access segment. At each frame, the proposed scheme dynamically switches from the assignment-based segment to the random access segment taking into account the traffic parameters of the devices. The assignment-based segment is suitable for devices with high packet arrival probabilities, and the random access segment is more efficient for devices with infrequent packet arrivals. To assign devices to the proper segment, the problem is formulated as a complementary geometric programming problem, where the solution can be obtained by applying a computationally affordable algorithm.

In addition, reinforcement learning algorithms are used for scenarios of unknown traffic parameters. More specifically, for these scenarios, Thompson sampling-based algorithms are proposed and regret analysis is conducted for performance evalua-

tion. Furthermore, the performance of the proposed reconfigurable access scheme is investigated in a scenario in which devices use different wireless technologies to access the channel. In particular, we consider the case that all devices transmit over the same unlicensed channel, where some of them are connected to the long-term evolution (LTE) network while others use WiFi technologies to access the channel. Moreover, to further boost the performance of the proposed reconfigurable access scheme and accommodate connectivity of a large number of devices, the proposed reconfigurable access scheme is enhanced with non-orthogonal multiple access (NOMA) technology. In particular, using optimization techniques, the proposed reconfigurable access scheme, at each frame, chooses which devices to transmit their packets using NOMA, which to transmit in the orthogonal assignment-based segment, and what access parameters to be used for the rest of devices competing in the random access segment. Finally, to reduce the signaling overhead, a self-organized TDMA scheme is proposed in which devices reserve time-slots without the need of a central entity.

This book addresses the main challenges that exist in MTC systems, in particular focusing on the problems related to the design of proper multiple access schemes for these systems.

This work was partially supported by the Natural Sciences and Engineering Research Council (NSERC) and the Huawei Technologies Canada.

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May 2020

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Acronyms

AGMA	Arithmetic geometric mean approximation
AP	Access point
BS	Base station
CGP	Complementary geometric programming
CMAB	Combinatorial multi-armed bandit
CSMA	Carrier sense multiple access
DEB	Deterministic backoff
DFA	Demand/free assignment
GP	Geometric programming
LTE	Long-term evolution
M2M	Machine to machine
MAC	Medium access control
MDP	Markov decision process
MTC	Machine-type communication
NERA	NOMA-enhanced reconfigurable access
NOMA	Non-orthogonal multiple access
OMA	Orthogonal multiple access
PDR	Packet delivery ratio
QoS	Quality of service
RA	Random access
RCA	Reconfigurable access
SIC	Successive interference cancellation
TDMA	Time division multiple access
TMAB	Thresholding multi-armed bandit
TS	Thompson sampling
U-LTE	Unlicensed LTE