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Non-Orthogonal Multiple Access for Massive Connectivity

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How to support massive number of devices for future wireless networks?

Foreword

Non-orthogonal multiple access (NOMA) holds great promise for meeting the phenomenal increase in demand for both wireless user access and capacity, fueled by the Internet of Things (IoT). Unlike orthogonal multiple-access schemes, in NOMA, multiple users can share the same time or frequency resource while being assigned different codes or power levels and separated at the receiver using successive interference cancelation techniques. *Non-Orthogonal Multiple Access for Massive Connectivity* is a much-needed reference on this critically important technology for 5G and beyond networks. This first-of-its-kind book from the experts on this subject presents a comprehensive framework for the design and analysis of power-domain NOMA divided into three main parts that address the key issues of compatibility, sustainability, and security. In the compatibility part, the authors masterfully demonstrate the seamless integration of NOMA with other key wireless technologies such as multi-input multi-output (MIMO) and its benefits when applied to cognitive radio networks and heterogeneous networks, where the whole becomes greater than the sum of its parts. In the sustainability part, the authors skillfully show how NOMA can be efficiently integrated with cooperative communication and simultaneous wireless information and power transfer (SWIPT) protocols to extend network reliability and lifetime. In the security part, the authors brilliantly analyze the physical layer security performance of NOMA networks and quantify the secrecy gains possible with the aid of artificial noise signals. Finally, the authors explore two exciting topics with lots of intriguing unanswered questions for future research; namely, the application of NOMA to unmanned aerial vehicle (UAV) networks and the exploitation of machine learning tools to further enhance the performance of NOMA-based wireless networks. This well-written book provides an in-depth treatment of the subject and strikes an excellent balance between theory and practice. It will serve as a valuable reference on NOMA for researchers and practicing engineers for years to come.

Richardson, TX, USA — Naofal Al-Dhahir
July 2019

Preface

In this book, we discuss NOMA and the various issues in NOMA networks, including capability, sustainability, and security. This book starts from the basics and key techniques of NOMA. Subsequently, we identify three critical issues in NOMA networks, including compatibility, sustainability, and security. Particularly, we first demonstrate the applications of NOMA in different networks including MIMO-NOMA, NOMA in heterogeneous networks, and NOMA in cognitive radio networks to show the compatibility of NOMA with various networks. Then, the wireless-powered NOMA networks are presented to address the sustainability issues in NOMA networks to extend the network reliability and lifetime. The security-enhanced NOMA networks are discussed for single antenna case and multiple antenna case, respectively. Finally, the most recent developments on artificial intelligence (AI)-enabled NOMA networks are discussed, and the research challenges on NOMA to support massive number of devices are identified. We believe this book will provide readers a clear picture on the performance and benefits of adopting NOMA for the next generation of wireless communication systems to support massive connectivity.

Acknowledgement

I would like to express my sincere gratitude to all the colleagues who contributed to the work and projects that led to this book.

I would also like to particularly thank our editor as well as all the editorial staffs from Springer for producing this book.

London, UK
April 2019

Yuanwei Liu

Contents

Acronyms

AF	Amplify-and-Forward
AI	Artificial Intelligence
AWGN	Additive White Gaussian Noise
BB	Beamforming-Based
BC	Broadcast Channel
BF	Beamforming
BS	Base Station
CB	Cluster-Based
CDF	Cumulative Distribution Function
CDMA	Code Division Multiple Access
CF	Compress-and-Forward
CIRs	Channel Impulse Responses
CoMP	Coordinated Multipoint
CR	Cognitive Radio
CSI	Channel State Information
CSIT	Channel State Information at the Transmitter
D2D	Device-to-Device
DF	Decode-and-Forward
DL	Downlink
FDMA	Frequency Division Multiple Access
IDMA	Interleave Division Multiple Access
IMD	Iterative Multi-user Detection
IoT	Internet of Things
LDPC	Low-Density Parity-Check
LDS	Low-Density Signature
LMMSE	Linear Minimum Mean Square Error
LPMA	Lattice Partition Multiple Access
LTE	Long Term Evolution
M2M	Machine-to-Machine
MA	Multiple Access
MAC	Medium Access Control

ML	Machine Learning
MNV	Wireless Network Visualization
MPA	Message Passing Algorithms
MUSA	Multi-User Shared Access
MUST	Multi-User Superposition Transmission
NP	Non-deterministic Polynomial time
NOMA	Non-Orthogonal Multiple Access
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OMA	Orthogonal Multiple Access
P2P	Peer-to-Peer
PA	Power Allocation
PDMA	Pattern Division Multiple Access
PLS	Physical Layer Security
PR	Primary Receiver
PT	Primary Transmitter
PU	Primary User
QoS	Quality of Service
RB	Resource Block
RBC	Relaying Broadcast Channel
RF	Radio Frequency
SA	Signal Alignment
SC	Superposition Coding
SCMA	Sparse Code Multiple Access
SDM	Space Division Multiplexing
SDMA	Space Division Multiple Access
SDN	Software-Defined Network
SD-NOMA	Software-Defined NOMA
SDR	Software-Defined Radio
SIC	Successive Interference Cancelation
SISO	Single-Input Single-Output
SNR	Signal-Noise Ratio
SR	Secondary Receiver
ST	Secondary Transmitter
SU	Secondary User
SWIPT	Simultaneous Wireless Information and Power Transfer
TCMA	Trellis Coded Multiple Access
TDMA	Time Division Multiple Access
UL	Uplink
WPT	Wireless Power Transfer
ZF	Zero-forcing