

Cloud Radio Access Networks

Principles, Technologies, and Applications

Understand the fundamental theory, current techniques, and potential applications of cloud radio access networks (C-RANs) with this unique text. Leading experts from academia and industry guide you through all of the key elements of C-RANs, including system architecture, performance analysis, technologies in both the physical and medium access control layers, self-organizing and green networking, standards development, and standardization perspectives. Recent developments in the field are covered, as well as open research challenges and possible future directions.

The first book to focus exclusively on cloud radio access networks, this is essential reading for engineers in academia and industry working on future wireless networks.

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Cambridge University Press
978-1-107-14266-4 — Cloud Radio Access Networks
Edited by Tony Q. S. Quek , Mugen Peng , Osvaldo Simeone , Wei Yu
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“This is the first book that covers the fundamental theory, current techniques, and applications of cloud radio access networks. The coverage is balanced and the topics are very timely. . . This book should be an essential reading for graduate students, engineers, and researchers who are interested in exploring this important field of wireless communication research.”

Zhi-Quan Luo, The Chinese University of Hong Kong, Shenzhen

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CAMBRIDGE UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom
One Liberty Plaza, 20th Floor, New York, NY 10006, USA
477 Williamstown Road, Port Melbourne, VIC 3207, Australia
4843/24, 2nd Floor, Ansari Road, Daryaganj, Delhi – 110002, India
79 Anson Road, #06–04/06, Singapore 079906

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org

Information on this title: www.cambridge.org/9781107142664

DOI: 10.1017/9781316529669

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First published 2017

Printed in the United Kingdom by TJ International Ltd, Padstow, Cornwall

A catalogue record for this publication is available from the British Library.

ISBN 978-1-107-14266-4 Hardback

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Acknowledgments

First, we would like to express our sincere gratitude to all our contributors, without whom this book would never have been produced. Indeed, it was a great pleasure for us to have such high-quality contributions from prominent researchers in the field of wireless networks. Our contributors, as they appear in the book, are as follows: Tony Q. S. Quek, Mugen Peng, Osvaldo Simeone, Wei Yu (editors), Chih-Lin I, Jinri Huang, Ran Duan, Sadayuki Abeta, Wuri A Hapsari, Kazuaki Takeda, Peter Rost, Matthew C. Valenti, Salvatore Talarico, Andreas Mäder, Pratik Patil, Binbin Dai, Yuhan Zhou, Zhen-dong Mao, Yourrong Ban, Di Chen, Shi Jin, Jun Zhang, Kai-Kit Wong, Hongbo Zhu, Yuanming Shi, Jun Zhang, Khaled B. Letaief, Bo Bai, and Wei Chen, Seok-Hwan Park, Onur Sahin, Shlomo Shamai Shitz, Thang X. Vu, Hieu D. Nguyen, Shao-Yu Lien, Shao-Chou Hung, Chih-Hsiu Zeng, Hsiang Hsu, Qimei Cui, Kwang-Cheng Chen, Ahmed Douik, Hayssam Dahrouj, Oussama Dhifallah, Tareq Y. Al-Naffouri, Mohamed-Slim Alouini, Jian Li, Hongyu Xiang, Yuling Yu, Jian Zhao, Zhongding Lei, Sheng Zhou, Jingchu Liu, Tao Zhao, Zhisheng Niu, Yuanzhang Xiao, Mihaela van der Schaar, Haijun Zhang, Julian Cheng, Victor C. M. Leung, Kenza Hamidouche, Walid Saad, Merouane Debbah, Sau-Hsuan Wu, Hsi-Lu Chao, Hsin-Li Chiu, Chun-Hsien Ko, Yun-Ting Li, Ting-Wei Chang, Tong-Lun Tsai, Che Chen, Min Yan, Xiaogen Jiang. We would like to thank Cambridge University Press staff and in particular Julie Lancashire and Heather Brolly for their continuous encouragement and support during the course of this project.

Tony Q. S. Quek would like to thank his family and colleagues at the Singapore University of Technology and Design (SUTD) for their encouragement and support. He would also like to acknowledge funding support from the MOE ARF Tier 2 under grant MOE2014-T2-2-0 the MOE ARF Tier 2 under grant MOE2015-T2-2-10 and the SUTD-ZJ4 Research Collaboration under grant SUTD-ZJ4/RES/01/2014.

Mugen Peng would like to thank his family and to acknowledge fund support from the National Natural Science Foundation of China (Grant No. 61222103), the National High Technology Research and Development Program of China (Grant No. 2014AA01A701), and the National Basic Research Program of China (973 Program) (Grant No. 2013CB336600).

Osvaldo Simeone would like to acknowledge support from the US NSF under grant CCF-1525629.

Wei Yu wishes to acknowledge the support of the Natural Sciences and Engineering Research Council (NSERC) of Canada through a Collaborative Research

and Development grant, an E.W.R. Steacie Memorial Fellowship, and the Canada Research Chairs program. Wei Yu also wishes to acknowledge the support of Huawei Technologies Canada Co. Ltd.

Last, but not least, we would also like to sincerely thank Professor Vincent Poor for writing the foreword to the book.

Foreword

Wireless networking is one of the most advanced and rapidly advancing technologies of our time. The modern wireless era has produced an array of technologies of tremendous economic and social value and almost ubiquitous market penetration. A major contemporary focus of the community of researchers and engineers working on the development of new wireless technologies is the specification and design of the fifth generation (5G) of mobile communications. Among the envisioned features of 5G are an extremely large and heterogeneous population of connected devices communicating with humans or machines (or both) and having highly varied quality of service requirements in terms of latency, data rates, etc., leading to the so-called Internet of Things. To deal with this scale, density, and variety of use, new network architectures are being proposed for 5G. One of the most promising of these is the Cloud Radio Access Network (C-RAN), in which radio connectivity to end-users is provided via densely deployed low-complexity radio heads, and most signal processing tasks are performed in the cloud. This architecture enables the provision of much greater capacity, by allowing both the densification of radio resources and the implementation of sophisticated signal processing algorithms at scale, and doing so at substantially lower capital and energy costs than conventional base-station-centric cellular architectures would require. Edited by four leaders in the field, *Cloud Radio Access Networks: Principles, Technologies, and Applications* provides a comprehensive treatment of C-RANs, describing in the depth the overall C-RAN architecture, and the many physical layer, resource allocation, and networking challenges that arise in this important and innovative concept, together with potential solutions to these challenges. These advances are described in chapters written by leading contributors to their development, thus providing a clear and up-to-date exposition of the state of the art in C-RANs. As such, this volume should be of considerable interest to researchers and engineers looking to develop the next generation of mobile networking technologies.

H. Vincent Poor
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Preface

Cloud radio access networks (C-RANs) refer to a wireless cellular architecture in which all network functionalities of conventional base stations, apart from radio frequency operations and possibly analog–digital conversions, are carried out at a central cloud processor. The idea was relegated for many years to the realm of information- and communication-theoretic studies, which promised gains in terms of spectral efficiency thanks to the possibility of implementing joint baseband processing at the central processor. The main obstacles to the deployment of C-RAN-type systems were thought to be the high complexity of the necessary cloud processor as well as the limited availability of high-speed backhaul links connecting edge and cloud.

In recent years, advances in cloud computing and a more pervasive deployment of fiber optic cables and high-frequency wireless backhaul links towards the network edge have spurred the reconsideration, and eventually the implementation, of cloud-based radio access systems. In fact, as argued in the seminal white paper by China Mobile, not only can the C-RAN architecture reap the spectral efficiency gains promised by academic studies, it can also crucially reduce capital and operating expenses. This is a consequence of the centralization of network resources in the cloud: the complexity and cost of edge nodes can be drastically reduced with respect to conventional base stations, and updates and maintenance can be performed solely at the cloud.

As C-RAN moves from paper to the real world, industry and academia are working towards the definition of protocols and algorithms at all layers of the communication protocol stack, so as to enable cost-effective and high-performance cloud-based systems to be widely adopted as a leading solution for 5G networks.

This book is intended to provide a broad overview of the current research activity in the industry and academia on the subject of C-RANs. While this is an active field of study, involving theoreticians and practitioners, the editors believe that the current state of the art is sufficiently mature to warrant a monographic treatment. The book covers the architecture, physical-layer design, resource allocation, and networking of C-RAN systems, in separate parts each consisting of various chapters authored by leading researchers in both industry and academia.

It is our hope that this book will serve as a useful reference for engineers and students and that it will motivate more researchers to undertake the numerous open problems highlighted in the following pages.

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