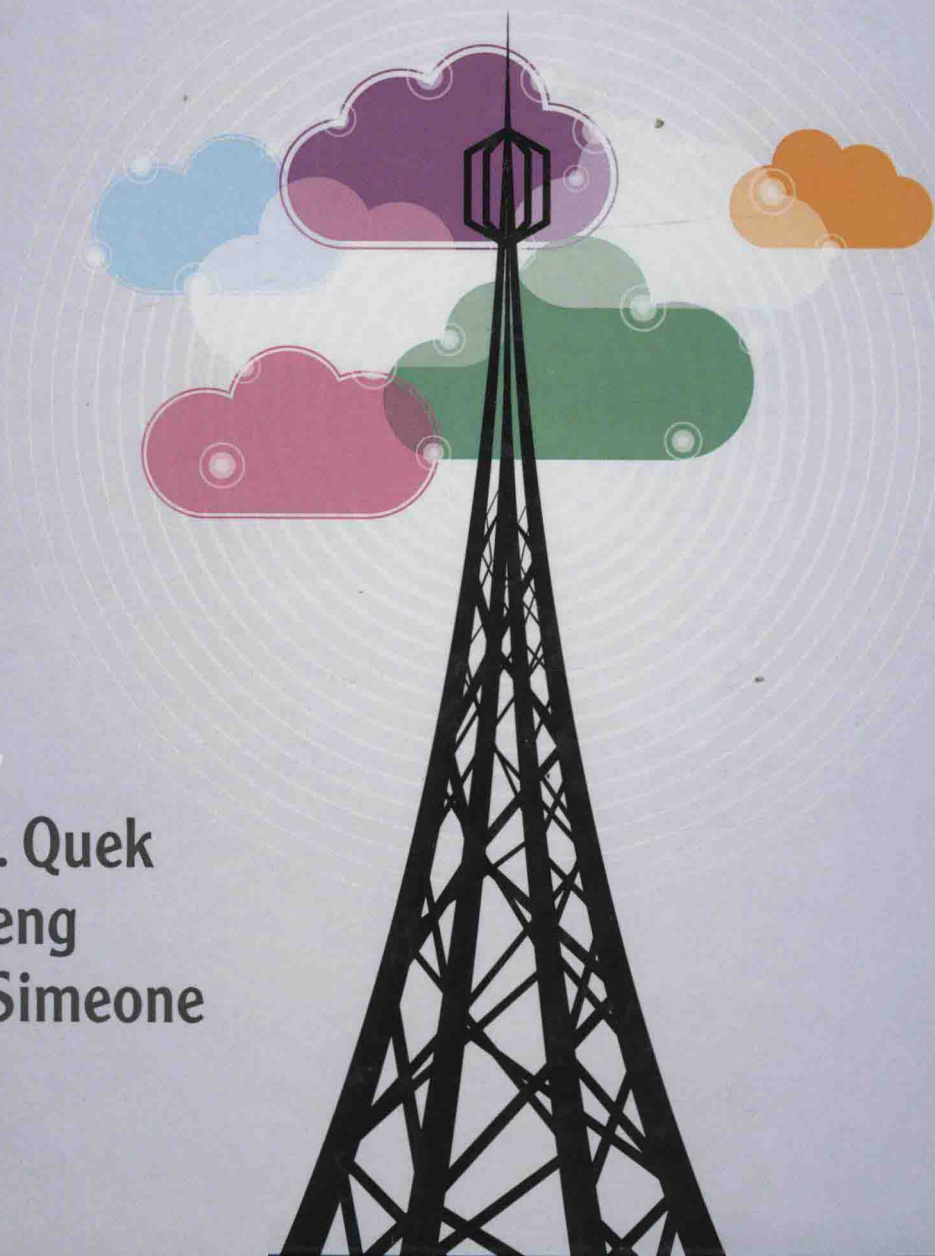


# Cloud Radio Access Networks

Principles, Technologies,  
and Applications

Edited by  
Tony Q. S. Quek  
Mugen Peng  
Osvaldo Simeone  
Wei Yu



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

"... essential reading for graduate students, engineers, and researchers who are interested in exploring this important field of wireless communication research."

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.

**Tony Q. S. Quek** is an Associate Professor in the Information Systems Technology and Design Pillar at the Singapore University of Technology and Design. He is a Senior Member of the IEEE and a co-editor of the book *Small Cell Networks* (Cambridge, 2013).

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## Principles, Technologies, and Applications

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

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# 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  
Princeton, New Jersey



# 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.

Tony Quek, Mugen Peng, Osvaldo Simeone, and Wei Yu

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