# Chapter 1 MIMO Hybrid Beamforming: Performance Assessment in Macrocells and HetNets

Mostafa Hefnawi Royal Military College of Canada, Canada

#### Jamal Zbitou

(D) https://orcid.org/0000-0002-3118-8929 LABTIC ENSA of Tangier, University of Abdelmalek Essaadi Tetouan, Morocco

## ABSTRACT

In mmWave massive MIMO, the required number of radio frequency (RF) chains becomes impractical due to the expensive and power-hungry components such as variable gain power amplifiers, filters, mixers, and analog-to-digital/digital-to-analog converters (ADCs/DACs). A promising solution to this problem is reducing the number of radiofrequency (RF) chains by partitioning beamforming operations between the digital and RF domains, known as hybrid beamforming (HBF), while still achieving the nearoptimal performance of the fully digital beamforming systems with much-reduced hardware complexity. This chapter reviews different HBF techniques for massive MIMO in 5G and radar systems. The basic HBF structures and their algorithm design is presented in the context of a point-to-point MIMO hybrid beamforming system. Then, some recently proposed HBF techniques for 5G and beyond networks are investigated, followed by a discussion about the benefit of HBF in MIMO radar systems.

# INTRODUCTION

Recently, millimeter-wave (mmWave) massive multiple-input multiple-output (MIMO) systems have emerged as a promising solution to enhance the network capacity and coverage of the new generation cellular networks (Marzetta, October 2010; Rusek, 2013; Hoydis, 2013; Busari, 2018). On the one hand, the mmWave can provide a considerable bandwidth; on the other hand, the significant gain of the massive arrays can compensate for the attenuation of the mmWave channel. Traditional MIMO-beamforming systems require a dedicated radio frequency (RF) chain for each antenna element to achieve optimal

DOI: 10.4018/978-1-6684-5955-3.ch001

beamforming performance. However, in mmWave massive MIMO, the required number of radio frequency (RF) chains becomes impractical due to the expensive and power-hungry components such as variable gain power amplifiers, filters, mixers, and analog-to-digital/digital-to-analog converters (ADCs/ DACs). A promising solution to this problem is reducing the number of radiofrequency (RF) chains by partitioning beamforming operations between the digital and RF domains, known as hybrid beamforming (HBF), while still achieving the near-optimal performance of the fully-digital beamforming systems with much-reduced hardware complexity (Sohrabi, F., Yu, W., 2016; El Ayach, O., 2014; Alkhateeb, A., 2014, 2015; Liang, L.,2014; Ni, W., 2017; Hefnawi, M., 2019; Kebede, T., 2022). In HBF, the RF analog beamformer is typically limited to applying phase shifters only to each array element, while digital beamforming with complex weighting vectors can be applied on each RF chain. Figure 1 shows a general hybrid configuration that connects  $N_a$  antenna elements to  $N_d$  RF chains, where  $N_d < N_a$ , using an analog RF beamforming matrix built from only phase shifters.





Figure 2. Architectures of analog beamformers: (a) Fully-connected; (b) partially-connected



26 more pages are available in the full version of this document, which may be purchased using the "Add to Cart" button on the publisher's webpage:

www.igi-global.com/chapter/mimo-hybrid-beamforming/317783

## **Related Content**

#### Secure Node Localization in Mobile Sensor Networks

Rachit Mittaland Manik Lal Das (2014). *International Journal of Wireless Networks and Broadband Technologies (pp. 18-33).* www.irma-international.org/article/secure-node-localization-in-mobile-sensor-networks/104628

WiFiMon: A Tool for Wi-Fi Performance Monitoring and Verification Christos Bouras, Kurt Baumann, Vasileios Kokkinos, Nikolaos Papachristosand Kostas Stamos (2019).

International Journal of Wireless Networks and Broadband Technologies (pp. 1-18). www.irma-international.org/article/wifimon/237188

#### The Outdoor Wireless Healthcare Monitoring System for Hospital Patients Based on ZigBee

Xiaoxin Xu, Mingguang Wu, Bin Sun, Jianwei Zhangand Cheng Ding (2012). *Wireless Technologies: Concepts, Methodologies, Tools and Applications (pp. 1293-1305).* www.irma-international.org/chapter/outdoor-wireless-healthcare-monitoring-system/58842

# Compact Printed Antenna With Loaded and Etched Bandstop Resonators: Applications in UWB Spectrum

Mohamed Hayouniand Fethi Choubani (2023). *Handbook of Research on Emerging Designs and Applications for Microwave and Millimeter Wave Circuits (pp. 79-96).* www.irma-international.org/chapter/compact-printed-antenna-with-loaded-and-etched-bandstop-resonators-applicationsin-uwb-spectrum/317786

### Evolutionary Malware: Mobile Malware, Botnets, and Malware Toolkits

Michael Brian Pope, Merrill Warkentinand Xin (Robert) Luo (2012). *International Journal of Wireless Networks and Broadband Technologies (pp. 52-60).* www.irma-international.org/article/evolutionary-malware/90277