Chapter 11
Beamforming for Relay Assisted MIMO

Abdul Sattar Saand
Quaid-e-Awan University of Engineering, Pakistan

Varun Jeoti
Universiti Teknologi PETRONAS, Malaysia

Mohamad Naufal Mohamad Saad
Universiti Teknologi PETRONAS, Malaysia

ABSTRACT

In cellular wireless communication systems, the current and future networks are promising to provide multimedia services at the cell edges and beyond the cell boundaries efficiently and cost effectively. The relay assisted MIMO networks have got much attraction to meet the requirements by providing high capacity, link reliability and high quality of service. The performance of the relay assisted networks is maximized by making the use of beamforming design at the relay nodes. This chapter describes the recent developments in relay beamforming design for Amplify-and-Forward (AF) relay networks and introduces a new beamforming scheme to improve the network performance in terms of ergodic capacity. The chapter contributes in introduction to basic MIMO channel, various relaying strategies and introduction to relay assisted network topologies. It is followed by critical literature review on AF beamforming techniques. This leads towards the novel and efficient relay beamforming design, its performance evaluation and validity by comparing with various available beamforming techniques.

INTRODUCTION

The emerging trend of the wireless technologies is being attracted by the current and future wireless communication networks due to their significant merits, that can meet the requirement of providing high data rate at anytime and anywhere basis. Among them the merger of MIMO and relaying technologies are much attracted by 3G, 4G, LTE advanced networks, WiMAX and massive MIMO system. The massive MIMO is assumed to be a strong candidate of the 5G and beyond.

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In wireless communication the channel capacity, quality and reliability is depraved due to multipath fading, shadowing, path loss and signal interference effects. To tackle the problems an alternate to increase the number of base stations that decrease the distance between two points but requires heavy capital and running expenditures, a relay assisted transmission technique is being considered as a lucrative and reliable solution to the problems for current and future wireless communication systems. This can enhance base station coverage, capacity at the cell edges and improves wireless link quality and reliably.

In relay assisted transmission, the source transits its information signal to the relay node, the relay multiplies beamforming matrix with the received signal and forwards it to destination. The enactment of the relay based MIMO networks can be further enhanced by using modern signal processing techniques called beamformings. In spatial domain it also can be interpreted as a linear filtering. The beamforming techniques are utilized to offer high data rate at relay receiver and to suppress the cochannel interference which results in signal to interference plus noise ratio maximization (Chandra, Bose, & Bose, 2011; Chen, 2013; Sanguinetti, D'Amico, & Rong, 2012).

In literature several beamforming designs are proposed to control the interference and noise level in AF relay assisted network. Among them well recognized beamforming techniques are matched filter, Zero forcing, and regularized zero forcing and minimum mean squared error. In relay receive beamforming zero forcing technique can cancel interference at the cost of noise enhancement. However the MF beamforming maximizes the signal-to-noise ratio (SNR) by minimizing noise without considering interference cancellation. At the relay downlink, using conventional relay downlink precoding techniques such as RZF and MMSE beamforming methods an improved performance can be acquired at the cost of interference level subject to the noise power by regularization of the pseudo inverse. Therefore it is always required to design a beamforming scheme that takes in account the interference and noise in the relay beamforming for better system performance.

This chapter presents a contextual on MIMO technology and an extensive review on beamforming designs for AF relay. A novel relay beamforming algorithm based on signal to interference plus noise ratio maximization based relay receive beamforming and signal to leakage plus noise ratio based relay transmit precoding using Fukunaga Koontz Transform (FKT) is proposed. This is used to unravel the problems of cochannel interference at the relay reception and interference due to the leakage signal at the destination. The ergodic capacity performance of the system can be improved with the proposed linear beamforming design.

BACKGROUND

The main application scenario of the relaying transmission is found in cellular wireless communication systems for capacity and coverage extension. Mostly the wireless communication networks experience three fundamental problems interdependently which are coverage, capacity and interference (Dohler & Li, 2010). In terms of capacity and endorsed transmit power, a limited amount of resources are assigned to a base station to serve a pre-defined number of users. However, with the growing number of users, the offered capacity becomes inadequate and results in unsatisfactory service. The limitation on transmit power causes inadequate power at the cell edge. The users at cell edge are suffered from neighbouring interference users and cells. The relays have proved to be the best and cost effective solution to alleviate these problems other than micro base station concept of solving the problems of capacity and coverage.