Cooperative Communication Systems Using Distributed Convolutional-Based Coding

Mohamed Mustafa Mohamed Elfituri

- Distributed space-time coding
- Decode-and-forward
- Amplify-and-forward
- Channel estimation
- Relay channels

SciencePG
Science Publishing Group

Cooperative Communication Systems Using Distributed Convolutional-Based Coding

Mohamed Mustafa Mohamed Elfituri

SciencePG
Science Publishing Group

Science Publishing Group

548 Fashion Avenue
New York, NY 10018
www.sciencepublishinggroup.com

Published by Science Publishing Group 2015

First Edition

ISBN: 978-1-940366-40-1

To order additional copies of this book, please contact:
Science Publishing Group
book@sciencepublishinggroup.com
www.sciencepublishinggroup.com

Printed and bound in India

To My Parents

for Their Love and Patience

Acknowledgments

Numerous people supported and helped me during the development of my book. A few words mention here cannot adequately capture all my appreciation.

First and foremost, I would like to dedicate this book to my parents, who, from the day I came to the world, have provided me tremendous support and constant encouragement. Their love and support are always the greatest inspiration to me, and without these, it would not have been possible for me to complete this work.

I would like also to thank my wife and my kids for their love, encouragement, and care during my difficult time.

Finally, I would like to thank all my friends who encouraged me throughout my work in College of Electrical and Electronics Technology.

Introduction

Whenever size, power, or other constraints preclude the use of multiple-input multiple-output (MIMO) systems, wireless systems cannot benefit from the well-known advantages of space-time coding (STC) methods. Also the complexity (multiple radio-frequency (RF) front ends at both the transmitter and the receiver), channel estimation, and spatial correlation in centralized MIMO systems degrade the performance. In situations like these, the alternative would be to resort to cooperative communications via multiple relay nodes. When these nodes work cooperatively, they form a virtual MIMO system. The destination receives multiple versions of the same message from the source and one or more relays, and combines these to create diversity. There are two main cooperative diversity techniques for transmission between a pair of nodes through a multiple relay nodes: decode-and-forward (DF) and amplify-and-forward (AF) modes. In the DF mode, the signal received from the source node is demodulated and decoded before retransmission. In the AF mode, the relay node simply amplifies and retransmits the signal received from the source node. No demodulation or decoding of the received signal is performed in this case.

In uncoded cooperative communication networks, the diversity of the system degrades significantly. This diversity degradation is attributed to the errors made at the relay nodes. Consequently, if better reliability is achieved at the relay nodes, the diversity may improve, or even may be preserved, as compared to the error-free case.

In this book, we present a coding scheme suitable for cooperative networks where the source and relays share their antennas to create a virtual transmit array to transmit towards their destination. We focus on the problem of coding for the relay channels. While the relays may use several forwarding strategies, including

AF and DF, we focus on coded DF relaying. We derive upper bounded expressions for the bit error rate (BER) assuming M−ary phase shift keying (M−PSK) transmission and show that the proposed scheme achieves large coding gains and full diversity relative to the coded non-cooperative case for a wide range of signal-to-noise ratio (SNR) of interest.

To improve the detection reliability further, we consider antenna/relay selection on the performance of cooperative networks in conjunction with the distributed coding scheme proposed. For simplicity, we assume that there is one relay that is equipped with n_R antennas and only the best antenna is selected. For this scenario, assuming DF and AF relaying, we derive upper bounds on the BER for M−PSK transmission. Our analytical results show that the proposed scheme achieves full diversity for the entire range of BER of interest, unlike the case without antenna selection.

In the last part of the book, we consider the same system considered in the ideal case but now with system imperfections. In particular, we consider the case when the channel state information is estimated at all nodes involved in the transmission process. We derive upper bounds on the performance with imperfect channel estimation. Our results show that there is performance degradation due to the presence of channel estimation error. However, the observations made in the case of ideal channel state information still hold for the non-ideal case.

In Chapter I, we introduce the definition of wireless systems, fading, and diversity.

Chapter II presents some background material and a review of previous work in cooperative communication. First, we begin with a brief description on the uncoded DF and AF single-relay channels and introduce three different time-division multiple-access (TDMA)-based protocols, as well as the corresponding channel and signal models. We also review several important coded cooperation schemes, and previous works which lead to the development of the new scheme. Later, we present simulation results for these three protocols and coded cooperation using binary phase shift keying (BPSK) transmission. Finally, we present a review of existing works in antenna selection and channel estimation.

In Chapter III, we introduce the proposed distributed coded cooperation scheme for relay channels. Assuming M -PSK transmission, we analyze the performance of the proposed distributed coded cooperation scheme and show that it achieves large coding gains and full diversity relative to the coded non-cooperative case. Also, we investigate the outage probability of the achievable rate of the DF relay channels in a Rayleigh fading environment. Finally, we derive expressions for the BER upper bound and the outage probability in the case of error-free and erroneous relaying.

Chapter IV considers antenna/relay selection in conjunction with the distributed coding scheme introduced in Chapter III in an effort to improve the detection reliability at the relay nodes. We show that performing antenna selection preserves the diversity order of the system for a wider range of SNR, which translates to significant coding gains over systems without antenna selection. Our analytical results show that the proposed scheme achieves full diversity for the entire range of bit error rate of interest, unlike the case without antenna selection.

In Chapter V, we study a channel estimation strategy for the distributed coding scheme, described in Chapter III. We also use Alamouti scheme for the distributed space-time coding cooperation in the second frame. Finally, we derived expressions for the BER upper bound in the case of error-free and erroneous relaying with imperfect channel estimation.

Contents