Resource Allocation for Multi-cell OFDMA Based Cooperative Relay Network

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STATEMENT OF ORIGIN

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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Abstract

Cooperative communications is emerging as an important area within the field of wireless communication systems. The fundamental idea is that intermediary nodes, called relay stations (RSs), who are neither the data source nor destination, are used to assist in communication between sender and receiver. In order to maximise their performance, networks which employ RSs require a new resource allocation and optimisation technique, which takes the RSs into account as a new resource.

Several proposals have been presented for the purpose of optimising the distribution of available resources between users. These proposals were developed based on various network scenarios and assumptions. In most cases, impractical assumptions such as; inter-cell interference (ICI) free and full availability of channel state information (CSI) were considered. However, the need for more robust, fair and practical resource allocation algorithms motivated us to study the resource allocation algorithm for OFDMA based cooperative relay networks with more realistic assumptions.

This thesis focuses on the resource allocation for the uplink OFDMA based cooperative relay networks. Multiple cells were considered, each composed of a single base station (destination), multiple amplify and forward (AF) relay stations and multiple subscriber stations (sources). The effects of inter-cell interference (ICI) have been considered to optimise the subcarrier allocation with low complexity. The optimisation problem aims to maximise the sum rate of all sources while maintaining a satisfactory degree of fairness amongst them.

Furthermore, a utility based resource allocation algorithm has been developed

assuming full and partial channel state information for the interference limited OFDMA-based cooperative relay network. In the proposed algorithm, relay selection is initially performed based on the level of ICI. Then, subcarrier allocation is performed on the basis of maximum achieved utility under the assumption of equal power allocation. Finally, based on the amount of ICI, a modified waterfilling power distribution algorithm is proposed and used to optimise the subcarrier power allocation across the allocated set of subcarriers.

This thesis also investigates the impact of the relay-to-destination channel gain on subcarrier allocation for uplink OFDMA based cooperative relay networks using multiple amplify-and- forward (AF) relaying protocols. The closed form outage probability is derived for the system under partial channel state information (PCSI) and considering the presence of inter-cell interference (ICI).

The proposed resource allocation algorithms as well as the mathematical analysis were validated through computer simulations and the results were presented for each chapter. The results show that, compared to conventional algorithms, the proposed algorithms significantly improve system performance in terms of total sum data rate, outage probability, complexity and fairness.

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LIST OF ACRONYMS

1^{st} G	First Generation
2^{nd} G	Second Generation
3^{rd} G	Third Generation
4^{th} G	Fourth Generation
AF	Amplify and Forward
AMPS	Advance Mobile Phone Service
AWGN	Additive White Gaussian Noise
BE	Best Effort
BPA	Binary Power Allocation
BS	Base Station
BTS	Base Transceiver Station
BW	Bandwidth
CDMA	Code Division Multiple Access
CF	Compress and Forward
CSI	Channel State Information
CSMA	Carrier Sense Multiple Access
DF	Decode and Forward
EF	Estimate and Forward
ETACS	European Total Access Communication System
FDD	Frequency Division Duplexing
FDMA	Frequency Division Multiple Access
FI	Fairness Index
FM	Frequency Modulation

GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
HSDPA	High-Speed Downlink Packet Access
ICI	Inter Cell Interference
ICI-RS	ICI-based Relay Selection
IFFT	Inverse Fast Fourier transform
LTE	Long Term Evolution
MA	Multiple Access
MAC	Medium Access Control
MAI	Multiple Access Interference
MIMO	Multiple Input Multiple Output
MMR	Mobile Multi-hop Relay
MRC	Maximum Ratio Combining
MS	Mobile Station
MUI	Multiuser Interference
NAK	Negative Acknowledgement
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiple Access
OSDMA	Orthogonal Space Division Multiple Access
PA	Power Allocation
PCSI	Partial Channel State Information
PDF	Probability Density Function
PHY	Physical
PSK	Phase-shift Keying
PSTN	Public Switched Telephone Network
QAM	Quadrature Amplitude Modulation
QOS	Quality of Service

RC	Rate Constraint
RD	Relay To Destination
RRM	Radio Resource Management
R-RS	Random Relay Selection
RS	Relay Station
SCI	Statistical Channel Information
SDMA	Space Division Multiple Access
SER	Symbol Error Rate
SINR	Signal to Interference and Noise Ratio
SMS	Short Message Service
SNR	Signal to Noise Ratio
SR	Source to Relay
TDD	Time Division Duplexing
TDMA	Time Division Multiple Access
W-CDMA	Wideband- Code Division Multiple Access
WF	Water-Filling
WiMAX	Worldwide Interoperability for Microwave Access

LIST OF SYMBOLS

P^k	Subcarrier's Power
P_T	Total power
$NC\chi^2$	Non-central Chi-square Distribution with Two Degrees of Freedom
ϵ^k	Estimation Error
$\Gamma(2(n+1))$	Gamma Function
$\gamma(a,b)$	Incomplete Gamma Function
$\gamma_{a,b}$	SNR Ratio Between a and b Channel
$\hat{h}^k_{a,b}$	Estimated Channel Gain between a and b Nodes
$\mathcal{G}_s$	Urgency Factor
ρ	Allocation Index
σ^2	Variance
${}_2F_1$	Hypergeometric Function
$D(.)$	Detrimental Function
FI	Fairness Index
g_r	RS Amplification Factor
$h^k_{a,b}$	Instantaneous Channel Gain between a and b Nodes
I	Interference
I_0	Zeroth-order Modified Bessel Function of the First Kind
$O(.)$	Complexity

P_{out}	Outage Probability
P_r	Probability
R	Data Rate
R_{min}	Minimum Data Rate Requirements
R_T	Total Data Rate
T_s	Time Slot
U	Utility Function
$y_{a,b}$	Received Signal at Node b From Node a

DEDICATION

To my parents and my family