IMPROVING FAIRNESS AND ENERGY EFFICIENCY IN CLOUD RADIO ACCESS NETWORKS THROUGH RESOURCES SCHEDULING AND POWER CONTROL

By

Mostafa Mohamed Abdelaziz Mohamed Ali AlEmam

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Electronics and Communications Engineering

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Key Words:
Fairness; Scheduling; CRAN; Interference

Summary:
In this work, we address the joint resources allocation and power control problem in cloud radio access networks (CRAN) with a focus on fairness between users and energy efficiency (EE). First, we proposed three algorithms to improve the fairness between users in CRAN. Simulation results show that the Minimum rate constrained algorithm reaches the optimal solution with complexity much less than the exhaustive search. However, the complexity of this algorithm is still high, so we proposed the other two heuristic algorithms, the weighted sum and the priorities algorithms. In the second part, we propose a multi-level algorithm to improve the EE in CRAN system. The EE solution includes a technique for switching small base stations (SBS) ON/OFF then solving optimization problem targets maximizing the EE for the down-selected BSs.

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Dedication

To my dear family, this work wouldn’t have been done without your support, thanks for everything you have done for me.

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List of Symbols and Abbreviations

α	Minimum rate constraint value per user
η	Power amplifier efficiency
A_{opt}	Assignments matrix of all users, RRHs and sub-bands
A	Assignments matrix of all users and RRHs
C	System throughput
C_{RRH}	Total throughput of all RRHs
C_{MBS}	Total throughput of MBS
D	Vector for all distances between users and RRHs
d_{avg}	Average distance between all users and RRHs
h_{luk}	Channel gain between RRH *l* and user *u* over sub-band *k*
J	Jain's fairness index
K	Number of sub-bands
K'	Number of sub-bands of MBS
K_C	The current sub-band of the sub-bands iterations.
L	Number of RRHs
N	Gaussian Noise Variance
P_0	Power consumption of MBS
P_{luk}	Transmission power of RRH *l* transmitting over sub-band *k.*
P_{luk*}	Obtained optimal transmission power
P_{RRH}	Total Power of RRH
P_S	Fixed operation power of RRH.

P_{RF}	Transmission power of RRH
Q	Number of switched ON RRHs
r_t	Average rate of all sub-bands and RRHs
r_u	Total rate of user u
R	Total system rate accumulated till the current sub-band averaged over the number of users.
s	Sum rate of the current assignment
s_w	Weighted sum rate of the current assignment
$SINR_{luk}$	Signal to noise plus interference for user u receiving from RRH l over sub-band k
U_R	Number of users suffering due to RRH switching off
U	Number of Users
$U_{interfer}$	Vector of all users with distance above d_{avg}
W_u	Weight of user u
x_{luk}	Assignment variable for user u, RRH l and sub-band k
y_l	Assignment variable for RRH ON/OFF

4G	Fourth Generation
5G	Fifth Generation
ASFR	Adaptive Soft Frequency Reuse
BBU	Base Band Unit
BS	Base station
CoMP	Coordinated MultiPoint

CQI	Channel Quality Indicator
CRAN	Cloud Radio Access Networks
CU	Central unit
DL	Downlink
E2E	End to End
EE	Energy Efficiency
eICIC	Enhanced Inter Cell Interference Coordination
HetNet	Heterogeneous Networks
ICIC	Inter Cell Interference Coordination
IoT	Internet of Things
LPN	Low Power Node
LTE	Long Term Evolution
MAC	Medium Access Control
MBS	Macro Base-station
MRC	Minimum Rate Constrained
OFDMA	Orthogonal Frequency Division Multiple Access
OPEX	Operational Expenses
PA	Power Amplifier
PFR	Partial Frequency Reuse
PMI	Precoding Matrix Indicator
QoS	Quality of Service
RB	Resource Block
RI	Rank Indicator

RRH	Remote Radio Head
RRM	Radio Resources Management
SDN	Software Defined Network
SFR	Soft Frequency Reuse
SINR	Signal to Interference plus Noise Ratio
UL	Uplink
WiFi	Wireless fidelity

Abstract

Cloud Radio Access Networks is one of the main trending technologies in the 5G. In CRAN, the system consists of clusters where each cluster has a centralized processing unit. This centralized unit provides the system with high interference mitigation capabilities where it collects all the information about user's status, so it can optimize the resources scheduling and transmission power. In some designs, this centralized unit is responsible also for the signal processing not only the scheduling. In our model, the scheduler is responsible for scheduling multiple cells based on scheduling algorithm where maximizing the system throughput is the main objective in most of literature work. We propose solutions for two well-known problems in CRAN, the fairness between users and improving the systems' Energy Efficiency. In the first one, we address the problem of fairness between users while optimizing resources' scheduling and power control in downlink CRAN. We consider different algorithms that focus on enhancing the fairness between users while maximizing the system sum-rate. The discussed problem is formulated as weighted sum rate over remote radio heads (RRHs), all the frequency sub-bands and all users, with a full frequency reuse between the RRHs. The results are compared based on the maximum system sum rate and Jain's fairness index. The thesis presents the optimal solution for the problem using minimum rate constrained algorithm which is compared with the exhaustive search solution in a small simulation environment. Due to the complexity limitation of the optimal solution, another two algorithms are presented, weighted sum algorithm and priorities algorithm. These solutions are compared with a baseline algorithm in larger problem based on the Matlab global search optimization toolbox. Simulation results show that the weighted sum algorithm achieves better Jain's fairness index than the