Accepted Manuscript

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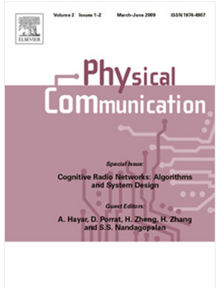

PII: S1874-4907(17)30558-X
DOI: https://doi.org/10.1016/j.phycom.2018.07.014
Reference: PHYCOM 580

To appear in: *Physical Communication*

Received date : 25 November 2017
Revised date : 13 June 2018
Accepted date : 16 July 2018

Iterative Resource Efficient Power Allocation in Small Cell Network

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***Abstract*—The major considerations in designing wireless networks are spectral efficiency (SE) and energy efficiency (EE). Though it is desirable to enhance both SE and EE, however, a trade-off exists between the two. To deal with this trade-off, a new metric called the resource efficiency (RE) has already been proposed in the literature. With RE as a performance evaluation metric, a balance can be struck between the SE and EE. Resource allocation with RE as an objective has already been proposed in the literature for a conventional cellular network. However, RE for a small cell network (a.k.a. heterogeneous network) has not been investigated yet. Small cells increase the frequency reuse factor, thus significantly enhancing the capacity and coverage of cellular networks. While already being embraced into LTE, the small cell technology will be one of the main features of the 5G cellular networks. In this paper, we investigate the problem of power allocation for a small cell network. An optimization problem is formulated with the objective of maximizing the RE such that maximum power constraint is satisfied. Finally, we propose an iterative heuristic method called the Iterative Resource Efficient Power Allocation (IREPA) algorithm to solve the formulated problem. We compare the performance of the IREPA algorithm with the Gradient Based Optimal Power Adaptation Scheme and the Uniform Power Allocation Scheme. Numerical results demonstrate the effectiveness of the proposed power allocation technique that significantly improves the resource efficiency.**

Index Terms*—*Energy efficiency, Spectral efficiency, Resource efficiency, Small cell networks, Power allocation

I. INTRODUCTION

One of the major challenges in wireless communication is the increased energy consumption due to data intensive applications such as high definition video streaming and other interactive services [1]. Excessive power consumption is a critical concern for the mobile operators. Therefore, green cellular networks have become a need for today's communication paradigm. Green cellular networks is an important research area for the future wireless communication systems. It has been predicted that wireless industry will be responsible for more than 0.7% of global CO_2 emissions, which may cause serious concern for the environment as well as for the sustained development of wireless communication. Green radio is an important research direction for future energy-efficient wireless networks. In the recent years, green radio technology has been the focus of several international collaborative projects including Mobile Virtual Centre of Excellence (MVCE) Green Radio Project [2] and Energy Aware Radio and network technologies (EARTH) [3] project.

The upcoming 5G cellular networks aim, to provide 1000 times higher system capacity, 10 times higher SE and much higher EE compared to the 4G network. For achieving these ambitious targets the use of small cells is a vital design choice along with several other technologies. However, with the increase in density of mobile network infrastructure, the power consumption can also increase, thus increasing the operating expenditure (OPEX) for the operator. Macro base stations (BSs) contribute to around 60% of the total energy consumption in cellular networks [4], [5]. Within this, a major portion of energy is consumed for RF signalling and the remainder is utilized for computational processing. Though small cells, including pico and femto cells BSs, consume much lesser energy as compared to macro BS, but due to the overall high density of small cell BSs, it is not clear whether they will be more energy efficient or not. Especially, while also considering the user deployed access points following the bring-your-own-device (BYOD) trend, which is very suitable for private and enterprise users. Nevertheless, improving the energy efficiency of the small cells deployed in conjunction with the macro cells remains a major concern for the operators to minimize their OPEX.

Spectrum efficiency is the optimum use of spectrum or bandwidth that allows transmission of maximum information (bits/sec) with minimum use of spectrum (Hz). Spectrum efficiency has been the main performance indicator for designing and optimizing wireless communication network and has been studied for various scenarios [6], [7]. Though massive MIMO technology is the major driver for SE improvement, as also shown recently by the team of 5G researchers at Bristol University, who were able to achieve a record breaking rate of 145.6 bits/s/Hz using a massive MIMO array thereby achieving a 22-fold increase in spectrum efficiency as compared to the 4G network. However, from an operator's perspective, spectrum efficiency has to be viewed in relation to the energy efficiency as the capacity requirements do vary over time and location.

Power allocation and resource allocation are well investigated topics for conventional [8] as well as small cell network [9]. Most of the studies work focus on the objective of maximizing either spectrum efficiency [10] or energy efficiency [11], [12], [13], [14], [15]. Energy efficiency has been analysed for single cell scenario [16], for single link optimization [14] and for the case of multi-cell deployment [17]. Energy efficiency and spectrum efficiency has also been jointly optimized for the cooperative green heterogeneous