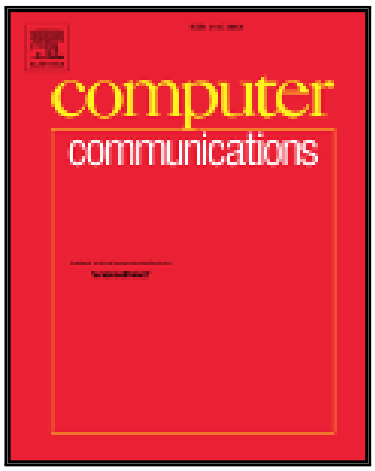

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Energy Efficiency of Network-Coding Enabled Mobile Small Cells

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***Abstract*— Energy efficiency becomes increasingly important due to the limited battery capacity in wireless devices while at the same time user throughput requirements are relentlessly increasing. In this paper, we study an energy efficient cooperation scheme which employs network coding to enhance the energy efficiency for mobile devices. Herein we propose that the mobile devices are clustered into mobile small cells with one of the mobile devices acting as a group head with basic transceiver, coding and relaying functionalities. Group heads coordinate the transmissions from the mobile devices in the mobile small cell to the network's base stations. The objective function of the cooperative scheme is to minimize mobile devices' energy consumption subject to a certain bit error probability. The proposed network-coding based scheme has been evaluated by means of numerical simulations and compared to both a conventional direct transmit scheme, with no cooperation groups, and a cooperative relaying scheme. Results show that, with network-coded cooperation, energy efficiency may significantly increase provided the density of base stations and mobile devices is below a certain value. Above this value none of the compared cooperation schemes may improve energy efficiency, but rather power consumption is reduced only when mobile devices transmit via base stations in their close proximity.**

Keywords—energy efficiency; network coding; cooperative transmission; mobile small cells

I. INTRODUCTION

Today's cellular networks are undergoing a major shift in their deployment and optimization due to an increasing number of connected devices and an unpreceded demand for wireless data traffic. This increasing density in traffic demand calls for further improvements in the efficiency of spatial reuse of spectrum resources [1]. Improving spectral efficiency requires a denser deployment of the radio access infrastructure and capacity-preserving transmission techniques [2].

Densification of a radio access network (RAN) implies the deployment of a large number of low-cost access nodes such as femto/pico base stations (BSs), fixed/mobile relays, distributed antennae, and radio heads (RHs). These may be connected to aggregation nodes by wireless links, which allows for the deployment of on-demand small cells, which are less involved than a full-functioning BSs, requiring mainly transceiver functionalities. The deployment of mobile devices to act as mobile small cells can further improve transmission capacity by employing cooperative schemes where user devices within the mobile small cell assist each other to cooperatively relay traffic.

A common concern with such solutions is the energy consumption of the mobile devices, which suffer from limited battery life time. Leveraging the mobile small cell paradigm, in this paper we study an energy efficient Network-Coded Cooperative (NCC) scheme between mobile devices, which is an extension of the network coding (NC) based cooperative solution introduced in [3]. The performance of our NCC solution is studied in the context of Dense Networks (DNs) for mobile devices of different power supply capabilities and for a varying density of base stations and mobile devices, which is an important factor to take into account when cells are formed. We compare our