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Smart energy management in mobile networks powered with renewable energies

Marco Miozzo[1*], Lorenza Giupponi[1], Michele Rossi[2] and Paolo Dini[1]

[1]*Centre Tecnològic de Telecomunicacions de Catalunya (CTTC),08006 Castelldefels, Spain*
[2] *Department of Information Engineering (DEI), University of Padova, Padova, Italy*

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Energy efficiency in cellular networks is becoming a key requirement for network operators to reduce their cost and to mitigate the carbon footprint of Information and Communication Technologies (ICT) on the environment. Costs and greenhouse gases emissions due to ICT grew in the last few years due to the escalation of traffic demand from mobile devices such as smartphones and tablets [1]. Network designers have been addressing this by considering hierarchical cell structures, through the so called heterogeneous networks (HetNets), where small cells are deployed to increase network capacity and decrease the overall energy consumption [2].

This paper aims to present new scenarios where harvested ambient energy is employed to steer HetNets toward *nearly-zero* energy consumption paradigm. With the term nearly-zero we mean that, in the long run, the costs incurred in operating the network are counterbalanced by the revenue from either grid energy savings or energy trading. The viability of a self-sustainable small cell networks has been discussed in [3] and can be achieved through the addition of rechargeable batteries and energy harvesting devices, such as solar panels. Here, we approach HetNets design from two different perspectives:

- Smart energy management for self-powering part of the network with auto-configuration capabilities thanks to machine learning techniques. The intermittent and erratic nature typical of renewable energies together with the variable traffic demand can be used for optimizing the network elements usage according to the actual network behavior, avoiding the over dimensioning of the system, thus reducing the cost of the equipment, deployment and maintenance. We show that machine learning solution can effectively adapt to changing environmental conditions and improve the energy efficiency of the system.
- Energy trading with the electricity grid or with other network elements. HetNets will operate within an energy market where the price of energy changes hourly and is set a day-ahead (as already done in Illinois nowadays). This allows for several new optimizations related to the way energy is consumed, purchased and possibly sold to the grid operator. Thus, we analyze whether the costs of providing these BSs with the needed solar add-on can be amortized and how long it takes to return the initial investments.

Keywords: energy efficiency, energy harvesting, energy trading, ICT, mobile networks.

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