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Resource Management in Cellular Base Stations Powered by Renewable Energy Sources

Faran Ahmed, Muhammad Naeem, Waleed Ejaz, Muhammad Iqbal, and Alagan Anpalagan

***Abstract*—This paper aims to consolidate the work carried out in making base station (BS) green and energy efficient by integrating renewable energy sources (RES). Clean and green technologies are mandatory for reduction of carbon footprint in future cellular networks. RES, especially solar and wind, are emerging as a viable alternate to fossil fuel based energy, which is the main cause of climate pollution. With advances in technologies, renewable energy is making inroads into all sectors including information and communication technologies (ICT). The main contributors of energy consumption in ICT sector are 'data centers' and 'cellular networks'. In cellular networks the BS is the main consumer of energy, mostly powered by the utility and a diesel generator. This energy comes at a significant operating cost as well as the environmental cost in terms of harmful greenhouse gas (GHG) emissions. Recent research shows that powering BSs with renewable energy is technically feasible. Although installation cost of energy from non-renewable fuel is still lower than RES, optimized use of the two sources can yield the best results. This paper presents a comprehensive overview of resource management in cellular BSs powered by RES and an in-depth analysis of power consumption optimization in order to reduce both cost and GHGs. Renewable energy sources are not only feasible for a stand-alone or off-grid BSs, but also feasible for on-grid BSs. This paper covers different aspects of optimization in cellular networks to provide reader with a holistic view of concepts, directions, and advancements in renewable energy based systems incorporated in cellular communications. Energy management strategies are studied in the realm of smart grids and other technologies, increasing the possibilities for energy efficiency further by employing schemes such as 'energy cooperation'. Finally, the paper supports the move towards green communication in order to contribute positively towards climate change.**

***Index Terms*—Cellular base station, energy optimization, green communication, renewable energy.**

I. Introduction

Over the past decade concepts such as renewable energy, energy conservation, and energy efficiency have found their way into all technology sectors including the information and communication technology (ICT) sector. The reason for this is twofold; firstly, the rising operating cost of power consumption for the energy intensive systems is being felt all over as technology encompasses every facet of our lives. Secondly, the ICT industry, being the fastest growing sector, realizes its obligation in reducing harmful CO_2 emissions attributed towards it. Amongst all sub-sectors of ICT, the telecomm sector in general and cellular communication in particular have shown huge potential for improvements in energy efficiency and converting systems on clean (renewable) sources of energy. As a result future communication is not only focused on spectrum management and throughput or quality of service (QoS) anymore. Rather, a new paradigm has come in, i.e., energy efficiency with reduced carbon footprint, called green communication [1]. Green communication has become a realistic goal for which new ways and means are being explored by the industry [2]–[6].

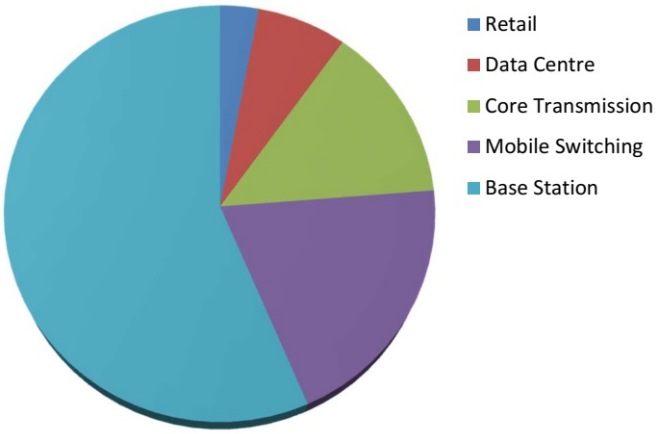

Fig. 1. Power consumption of cellular elements of mobile communication, with BS consuming upto 60% of network energy.

Cellular communication is the fastest growing component of telecom sector in particular and ICT in general [7], [8]. It is envisaged that the global BS power consumption will grow from 49 TWh in 2007 to 98 TWh by 2020 [9]. Improving energy efficiency in cellular networks involves energy reduction of all network elements, such as mobile core network, mobile switching centers, BSs, mobile back haul networks, and mobile terminals [10]–[19]. Amongst the mentioned elements, the BS is the most energy hungry component, consuming approximately 60% of the total energy consumed by cellular network [20], as depicted in Fig. 1. For the BS of a 3G and LTE network this ratio increases to 75-80% [2]. Thus, BSs have become the prime focus of research for energy efficiency in cellular communication; especially for installation of RES such as PV arrays and wind turbines.

Green wireless communication can be described as a set of concepts and frameworks put together to improve the energy

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