Chapter 5
Energy-Efficient Design of LTE Systems

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ABSTRACT

There has been a paradigm shift in the field of mobile communication, with an overwhelming increase in data usage. As more and more users are migrating to smartphones, the amount of data being transmitted has increased. However, huge amounts of data and signal propagation are bound to be detrimental to the ecological balance. Long-term evolution (LTE), due to its flexibility and backward compatibility, has emerged as the network of choice for 4G and beyond. In this chapter, the significance of core technologies for LTE network is highlighted, along with the inherent advantage of reducing the energy consumption of cellular network. An energy-efficient design of LTE is proposed that blends the technologies proposed by 3GPP such as adaptive OFDMA with that of MU-MIMO.

INTRODUCTION

With the ubiquitous proliferation of mobile communication, half the earth’s human population is actively using this technology. The evolution of mobile communication has witnessed a revolutionary trend over the last two decades. With the advent of

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more resilient technologies, the mobile industry has migrated from first generation (1G) to fourth generation (4G) Standards. These telecommunication standards are but defined rallying points (Kremecher, 1996). Advances in the field of digital communication have been fuelled by the need for higher data rates, supported by progress in solid state electronics (Viterbi, 1991). 3GPPs Long Term Evolution (LTE) has been declared as the fastest growing system in the history of mobile technology (Ericsson Mobility Report, 2012). By the year 2019, half the world’s population is expected to be covered by LTE network.

The birth of telecommunications is credited to Marconi in the year 1895, when he demonstrated the first radio transmission (Goldsmith, 2005). However, the growth of cellular communication matured gradually with the AT&T Bell Labs developing the cellular concept in the 1960s (Mac Donald, 1979).

The first generation (1G) standard, known as Advanced Mobile Phone System (AMPS) was developed in the year 1983, followed by 2G standards in 1990s (Rappaport, 2005). There was a fundamental shift in 1G to 2G cellular standards, since 2G marked the advent of digital wireless generation, whereas 1G was analog in nature. Global System for Mobile Communication (GSM), based on Time Division Multiple Access (TDMA), became the most popular 2G standard globally. Another 2G standard, IS-95, used Code Division Multiple Access (CDMA) as the air interface. CDMA provided capacity advantage and offered more resistance to interference as compared to TDMA (Lee, 1991). Thereby, CDMA was adopted as the air interface for 3G standards as a more flexible radio technology was required to meet the requirement of International Mobile Telecommunications 2000 (IMT 2000) standards (Carsello et al., 1997). The 3G standards offered significant enhancement in data speeds, defining a paradigm shift from voice to data communication. However, as the demand for higher data rates started pouring in, it was realized that CDMA is not suitable for high data rates (Zhang & Xu, 2007). Thus, Orthogonal Frequency Division Multiplexing (OFDM), which is a multi-carrier technology, gained consideration as the multiple access scheme for 4G standards (Roberts et al., 2006).

Since its invention by Chang (1966), OFDM has undergone many transformative changes. In their seminal work, Weinstein and Ebert (1971) proposed an easy implementation scheme of OFDM by means of digital signal processing. Peled and Ruiz (1980) advocated the use of cyclic prefix to further circumvent the effect of Inter Symbol Interference (ISI). Weinstein (2009) succinctly describes OFDM as Frequency division multiplexing in which sub-channels overlap without interfering. Another enabling technology for 4G wireless standards is Multiple Input Multiple Output (MIMO). Telatar (1995) demonstrates that the use of MIMO will boost network capacity. Mietzner et al. (2009) provide a comprehensive survey of multiple antenna techniques and it is demonstrated that there is a trade-off between Multiplexing and Diversity Gain. Multiplexing Gain (Figure 1) is the result of Spatial
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