Chapter 5
Collaborative Mobile Clusters: An Energy-Efficient Emerging Paradigm

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ABSTRACT

Future wireless communication systems are expected to offer several gigabits data rate. It can be anticipated that the advanced communication techniques can enhance the capability of mobile terminals to support high data traffic. However, aggressive technique induces high energy consumption for the circuits of terminals, which drain the batteries fast and consequently limit user experience in future wireless networks. In order to solve such a problem, a scheme called collaborative mobile cluster is foreseen as one of the potential solutions to reduce energy consumption per node in a network by exploiting collaboration within a cluster of nearby mobile terminals. This chapter provides a detailed analysis of the energy consumption of a terminal joining the cluster and also analyzes the conditions for energy savings opportunities.

1. INTRODUCTION

By utilizing new technologies for cellular environments, such as Orthogonal Frequency Division Multiple Access (OFDMA) in the downlink, Single-carrier Frequency-Division Multiple Access (SC-FDMA) in the uplink and multiple input multiple output (MIMO) schemes, the next generation wireless network is going towards offering high data rate multimedia services to the user. As the fast growth of wireless market, multicast/broadcast services, such as IPTV will become more popular. Meanwhile, the dramatic evolution of smart phones makes changes to how we use these mobile devices. For instance, the demand for sharing content among users, watching TV and other internet activities are surprisingly arisen. In this chapter, an emerging energy efficient paradigm, namely collaborative mobile cluster (CMC) is introduced to deal with such mobile evolution. The CMC model is foreseen as a potential platform to provide broadcast services and boost up sharing capabilities for mobile users with reduced energy consumption. In this section, next generation networks as well as some other background information are briefly overviewed.

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1.1. Background

The wireless communications industry has witnessed tremendous growth in the past decade with over four billion wireless subscribers worldwide. The first generation analog cellular systems supported voice communication with limited roaming capability. Later on, the second generation digital systems brought higher data rate and better voice quality than did their analog counterparts. The current third generation (3G) cellular network is offering high-speed data transmissions, such as VoIP, etc, to the mobile subscribers. In order to ensure the competitiveness of Universal Mobile Telecommunications System (UMTS) for the coming 10 years and beyond, concepts for UMTS Long Term Evolution (LTE) have been investigated. The focus of LTE is to provide a high-data-rate, low-latency and packet-optimized radio access technology supporting flexible bandwidth deployments (3GPP TR 25.913). In parallel, a new network architecture is designed with the goal to support packet-switched traffic with seamless mobility, quality of service and minimal latency (3GPP TR 23.882, 2009).

In the physical layer (PHY) of LTE, according to the initial requirements defined by the 3rd Generation Partnership Project (3GPP), the network should support peak data rates of more than 100 Mb/s over the downlink and 50 Mb/s over the uplink. A flexible transmission bandwidth ranging from 1.25 to 20 MHz will provide support for users with different capabilities. These requirements will be fulfilled by employing new technologies for cellular environments, such as OFDMA in the downlink, SC-FDMA in the uplink and multi antenna (or MIMO) schemes. Additionally, channel variations in the time/frequency domain are exploited through link adaptation and frequency-domain scheduling, giving a substantial increase in spectral efficiency. In order to support transmission in paired and unpaired spectrum, frequency division duplex (FDD) as well as time division duplex (TDD) modes are supported by the LTE air interface.

In the past, cellular systems (e.g. 1G) have mostly focused on transmission of data intended for a single user and not on broadcast services. Broadcast networks, exemplified by the radio and TV broadcasting networks, have on the other hand focused on covering large areas and have offered no or limited possibilities for transmission of data intended for a single user. In the next generation (e.g. 4G) networks, the support of broadcast or multicast service can be expected as an essential part and it is important for offering multimedia services to different users. For example, support of MBMS (Multimedia Broadcast Multicast Services) is a requirement for LTE and will be an integral part of LTE (3GPP TR 36.440, 2010).

1.2. Motivation

As expected, above mentioned future communication systems are going toward offering even gigabits data rate. In order to support such high data traffic, aggressive wireless technique will be utilized to the user equipments (UEs), which consequently induce high energy consumption (Chu, Chen & Fettweis, 2012). It is essential that these UEs can fully exploit the throughput gains offered by future communication systems whenever possible. Meanwhile, with the dramatic evaluations of smart phones, the way how people use cell phone is changing. Instead of simply making calls and sending short text messages, multimedia services are demonstrating the usage of cell phone. Moreover, due to the fact that the social medium and networks are becoming popular, the demand for sharing content among users is arisen as well.

On the other hand, the evaluation of wireless networks brings us facing many inherent problems. Telecommunications data volume increases
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