International Journal of Wireless Networks and Broadband Technologies
Volume 5 • Issue 1 • January-June 2016

Power-Aware and QoS Provisioned Real Time Multimedia Transmission in Small Cell Networks

Christos Bouras, Computer Engineering and Informatics Department, University of Patras, Patras, Greece & Computer Technology Institute & Press "Diophantus", Patras, Greece

Anastasios Bikos, University of Surrey, Guildford, UK

Dimitrios Bilios, University of Patras, Patras, Greece

Antonios Alexiou, Greek Ministry of Finance, Athens, Greece

ABSTRACT

The recent emergence of ultra-high-speed and high-definition data and video services has pushed wireless network capacity to its limits. Cellular network capacity is therefore a valuable resource, whereas indoor coverage poses itself as a challenging issue. At the same time, real-world paradigms of multimedia transmission require effective Quality-of-Service (QoS) provisioning as well as power admission. To confront issues like delay-sensitive QoS requirements and traffic provisioning, as well as meet the mobile customer needs, this paper presents a traffic-aware Orthogonal Frequency-Division Multiple-Access (OFDMA) hybrid small-cell deployment for QoS provisioning and an optimal admission control strategy for 4G cellular systems. The traffic awareness in the proposed framework is provided by a utility function, which differentiates the traffic QoS levels with the user's grouping priority indexes, channel conditions, and traffic characteristics. To further enhance the proposed framework, an admission power control algorithm based on an efficient algorithm handover is also proposed.

KEYWORDS

LTE, Power Control, Quality-of-Service (QoS), Radio Resource Allocation, Small Cells, Traffic Scheduling

1. INTRODUCTION

The recent growth of high demanding novel applications in terms of throughput and latency, has forced modern mobile operators to increase wireless coverage, boost data rates and capacity of their mobile networks. Undoubtedly, high definition multimedia communications and real-time traffic have become essential among them, thus issues like delay-sensitive Quality-of-Service (QoS) requirements and traffic provisioning are critical. The Long-Term Evolution Advanced (LTE-A), which is a part of the 4G cellular system deployments, can be seen as a reliable solution to fulfill these sophisticated requirements of multimedia and data traffic. More specifically, the existing wireless cellular architecture that consists of a single macrocell layer can be covered by several LTE-A-based small cells, which are deployed by low-power small-cell base stations. In the LTE terminology, Home evolved NodeB (HeNB) provide indoor cell coverage. The HeNB is a low power evolved NodeB's (eNB) that will be used in small cells. Home eNBs (HeNBs) are also known as femto cells, thus the terms HeNB and femto cell will be used equivalently in this paper. These LTE-A small cells (SCNs)

DOI: 10.4018/ijwnbt.2016010102

tend to increase network capacity through the spatial reuse of spectrum as well as improve indoor cellular coverage (Hoydis, Kobayashi, & Debbah, 2011), (Valcarce, de la Roche, & Jie, 2009).

Technical concerns and challenges, however, for SCNs are still unavoidable. Undoubtedly, a critical and detrimental problem facing SCNs is the presence of interference among neighboring SNCs, and between the SNCs and the macrocell LTE network. Total power capacity, being one of the most valuable resources inside SCNs, behaves as a performance evaluation criterion for wireless cellular systems. Inside traditional LTE networks, the eNB transmission power is a valuable and limited resource and must be fairly shared among all users in a cell. Thus, a beneficiary solution to deal with interference in SCNs is through power control optimization. The main purpose of power control is to minimize the transmitted power, thus avoiding unnecessary high power levels and eliminating intercell interference, as previously discussed. By appropriately adjusting the downlink transmission power per Resource Block (RB) that is required to obtain a target bit rate in femto cells, the overall generated interference in the SCN could be significantly reduced. In other words, Home evolved NodeB (HeNB) adjusts its transmission power so as to satisfy home user (HUE) Quality-of-Service (QoS), while protecting macrocell users (MUEs) in its vicinity, by keeping the interference below a threshold. QoS effectiveness among traffic users is also another key factor. QoS levels are easily mishandled on small cell networks without any provisioning. The QoS degradation is particularly large when the number of mobile users increases or when the mobile users are running bandwidth-hungry applications (Balakrishnan, & Canberk, 2014).

This paper makes a contribution by proposing an admission control procedure, inside a sophisticated LTE-A simulation framework, for efficient power allocation in SCNs. The proposed total framework efficiently controls systems' interference while on the other hand guarantees user QoS. The power admission control part of our implementation dynamically updates the HeNB power setting in real time based on the topology of the macro and home users as well as the requested traffic scenario by the users. An efficient handover over three standardized power control algorithms (3GPP TR 36.921, 2012) is being performed here from the dynamic determination of the most effective power switching points. It is proven that, depending on the examined traffic scenario, the power control mechanism can provide better protection (in terms of interference) either on macro users or on home users. Furthermore, we suggest a novel optimal allocation algorithm to perform QoS-based scheduling using traffic characteristics parameters as well as real-time network conditions. It is experimentally proven that when the number of femto users in the cell increases or when the traffic arrivals are outside the capacity region, the scheduler manages to handle fair allocation toward achieving end-user QoS. The implementation is evaluated through a user-friendly graphical tool designed to reproduce and calculate the optimal transmission parameters, via a graphical representation of the entire topology for a highly customizable network configuration.

2. RELATED WORK

A major portion of the existing literature has investigated the interference management issues of integrated LTE and Small Cell deployments. For example, Lopez-Perez et al. (2009) propose a scheme that adapts radio frequency parameters taking into account all the user and channel conditions. A novel backhaul-aware approach to interference management in wireless small cell networks is proposed in (Samarakoon, Bennis, Saad, & Latva-aho, 2013). The proposed approach enables macrocell user equipments to optimize their uplink performance, by exploiting the presence of neighboring small cell base stations. These studies have consistently shown that a coverage-hole exists when co-channel femto cells are deployed in a macrocell overlay network. Additionally, the studies have shown that