Range-Based Scheme for Adjusting Transmission Power of Femtocell in Co-Channel Deployment

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ABSTRACT

In heterogeneous networks, femtocells are introduced to improve the network capacity. However, dense deployment of femtocells leads to undesirable interference, which degrades the performance of the system. The interference can be managed and mitigated based on different approaches such as resource allocation or transmission power control. Controlling the femtocell transmission power is one of the factors that can be considered to alleviate undesirable effect of the interference. Also, it can be used to support auto-configuration conductance of the network. In this work, transmission power auto-configuration approach is proposed. The proposed approach is based on the macrocell transmission power and femtocell coverage. The simulation results depict that the capacity of the network is improved, and the interference is alleviated.

KEYWORDS

Autonomous Power Adjustment, Co-Channel Deployment, Cointerference. Downlink Transmission Power, Femtocell Network, Interference Mitigation, LTE, OFDMA, Power Control

1. INTRODUCTION

In recent years, the massive production of mobile applications has increased the demand on data services. In addition, a great amount of demanded data and voice services is claimed by users positioned in indoor places such as enterprise buildings. Long Term Evolution (LTE), which is a broadband network, provides advanced technical features and services. However, due to the penetration loss and long distance between User Equipment (UE), which is placed in indoor environment, and macrocell, the coverage of macrocell might not be worthy and meet UEs satisfaction. As a result, the notion of Home eNodeB (HeNodeB), also called femtocell or femto base station (FBS), is proposed and introduced to overcome the indoor environment deficiency of signaling. Correspondingly, femtocell entices the wireless industries interests and attentions (Chandrasekhar, Andrews, & Gatherer, 2008; Zhang et al., 2014). Femtocell expands the coverage of indoor environment as well as unloads traffic from macrocell. Femtocells are low power and low cost cellular networks. Also, femtocell can be deployed by the end users. Moreover, it uses licensed spectrum and uses backhaul connection to connect to the operators networks (Chandrasekhar et al., 2008). In addition, femtocell delivers high spectral efficiency, which is one of the features that can be achieved to enhance the UEs throughput.

Orthogonal Frequency Division Multiple Access (OFDMA) is a selected downlink transmission scheme that is introduced by 3GPP LTE. In terms of physical layer, the Physical Resource Block PRB is the basic unit, which is assigned for attached UEs. The critical key issue of deploying femtocell
and macrocell coexistence environment is the interference between cells. Due to the co-channel deployment, the interference will be experienced and lead to the systems performance limitation (Lopez-Perez, Valcarce, de la Roche, & Zhang, 2009). Subsequently, a useful approach is desired to mitigate the interference and resolve this challenge especially in dense deployment of femtocells. In femtocell networks, the setting and installment process is done by end users, which is preferable choice to diminish the cost on network operators.

Controlling femtocells power is one of the common methods and techniques that have been suggested to alleviate and avoid interference in heterogeneous networks. The femtocell power is low because it serves and covers limited areas such as residential homes and apartments, even though the dense and unplanned deployment of adjacent femtocells would cause interference among femtocells. Nevertheless, a mechanism for controlling the femtocell power is stimulated to be considered in order to mitigate the effect of interference among adjacent deployed femtocells. Many solutions have been proposed to handle this issue in previous works.

A comprehensive survey has been conducted in Palanisamy and Nirmala (2013). The authors have presented interference mitigation and avoidance in two-tier femtocell networks. In Li et al. (2015), femtocell is considered as agent to allocate a suitable power transmission level based on Q-Learning. Stochastic approximation mechanism is proposed in Wang, Zhu, and Ding (2016) where femtocell practices eavesdropping on nearby macro UE (MUE) signaling with macrocell to measure feedback approximation, and then femtocells set their downlink transmission power based on those estimations. In Cho, Kim, Jeon, Ryu, and Park (2011), the authors presented a novel method in order to set femtocell transmission power. The paper introduced a necessity of distinguishing between indoor and outdoor users and based on that discrimination, the femtocell determines its appropriate transmission power. Quadratic programming framework and cost index mechanism is proposed in Sanchez, Arauz, McClure, and Miller (2016). The suggested framework is built based on estimation of path losses between adjacent femtocells to set femtocells’ transmission power in a way of mitigating interference. In Shin and Choi (2012), the approximation of data traffic amount is considered in order to come up with autonomous transmission power adjustment method as well as preserving best coverage that femtocell can offer. The radio environment maps (REM), which is a database tool that contains collective information among distributed UEs and base stations, is used in Zalonis, Dimitriou, Polydoros, Nasreddine, and Mhnen (2012) in order to alleviate co-channel interference based on controlling the femtocell transmission power. The authors in Sun, Zhu, Zeng, and Wan (2011) propose self-power setting for femtocells based on signaling exchange between femtocells and macrocell. However, the communication between femtocells and macrocell that is necessary in order coordinate the interference problem is indirect, and that leads to over signaling and effects on systems performance. Therefore, femtocells set their transmission power based on cognitive radio (CR) to enhance the system capacity and mitigate the interference.

In this work, an autonomous downlink transmission power scheme for femtocells is proposed. Femtocells would be able to adjust its downlink transmission power based on their coverage, and it is derived according to macrocell coverage and transmission power. The rest of this paper is organized as follows. In the second section the system model is described. The procedure of the proposed mechanism is provided in the third section. Simulation results of the effectiveness of the proposed scheme is depicted and given in section four. In the last section, a brief conclusion of this work is given.

2. SYSTEM MODEL

In this work the problem of femtocell power control is considered to alleviate the effect of interference for cochannel deployment network. The femtocell network overview is shown in Figure 1. Macrocell/femtocell co-channel deployment is considered in this paper. There is a set \( N \) of all number of femtocell and \( N = \{ f_1, f_2, f_3, \ldots, f_n \} \). All femtocells are deployed in predefined coverage of a single macrocell.
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