Available online at www.sciencedirect.com
ScienceDirect
ICT Express 3 (2017) 132–136
www.elsevier.com/locate/icte

Max-throughput interference avoidance mechanism for indoor self-organizing small cell networks[☆]

Kuang-Hsun Lin[a], Cho-Hsin Tsai[b], Jen-Wei Chang[b], Yu-Chieh Chen[b], Hung-Yu Wei[b,*], Fu-Ming Yeh[c]

[a] *Graduate Institute of Communications Engineering, National Taiwan University, Taipei, Taiwan, ROC*
[b] *Department of Electrical Engineering, National Taiwan University, Taipei, Taiwan, ROC*
[c] *Gemtek Technology Co.,Ltd, Hsinchu, Taiwan, ROC*

Received 29 October 2016; received in revised form 20 March 2017; accepted 19 April 2017
Available online 6 May 2017

Abstract

Since mobile traffic has been growing recently, the deployment of indoor small cells has become an attractive solution to enhance coverage. However, the increasing density of cells makes inter-cell interference more considerable. In this paper, we propose a max-throughput Interference Avoidance (MTIA) centralized algorithm to improve the system's throughput. Based on signaling and reports, a central controller connected to each base station can properly turn off base stations that may induce a relatively strong interference, and thus increase SINR. We implemented the MTIA algorithm in an LTE TDD network simulation and showed that MTIA effectively reduces inter-cell interference and improves the system's throughput.

Keywords: Interference management; Self-organized network; Indoor; Small cell

1. Introduction

Since their advent ten years ago, smartphones have brought much convenience and influenced every aspect of our lives. However, the fact that the demand for higher capacity and data rates keeps exploding is a major challenge to current network operators. Cisco estimated that mobile data traffic has grown 4000-fold over the past 10 years and almost 400-million-fold over the past 15 years [1]. Clearly, existing cellular networks cannot meet such a tough demand and dense deployment of small cells must be made to augment fifth-generation (5G) systems [2]. Densifying a network can be done by deploying small cells, such as a microcell, picocell, femtocell, Distributed Antenna Systems (DAS), and relays [3]. In addition, a study shows that approximately 80% of wireless communications originates from indoor users [4]. Another research indicates that 30% of business and 45% of household users experience poor indoor coverage [5]. As a consequence, people have a greater need indoor small cells, often referred to as a femtocell [6]. These are a low-cost and low-power base stations, serving to provide indoor coverage and to transport user traffic over the Internet-based IP backhaul.

While indoor femtocells are expected to bring noticeable improvements on data rates [7], the inter-cell interference (i.e., interference coming from the neighboring femtocells) is non-negligible and can even be devastating. For one thing, they are deployed close to one another. The range of a femtocell is in the order of ten meters [8] and therefore it is very unlikely that interference would be canceled. For another thing, unlike macrocells, which are planned and managed by network operators, femtocells can be installed by users in a random manner, making it impossible to evaluate and avoid interference in advance. In the unfortunate case that there are femtocells separated by very thin walls, the total interference observed at a femtocell can be more serious than any of the individual

* Corresponding author.
E-mail address: hywei@cc.ee.ntu.edu.tw (H.-Y. Wei).

Peer review under responsibility of The Korean Institute of Communications Information Sciences.

☆ This paper has been handled by Prof. Francesco Potorti.

http://dx.doi.org/10.1016/j.icte.2017.04.005

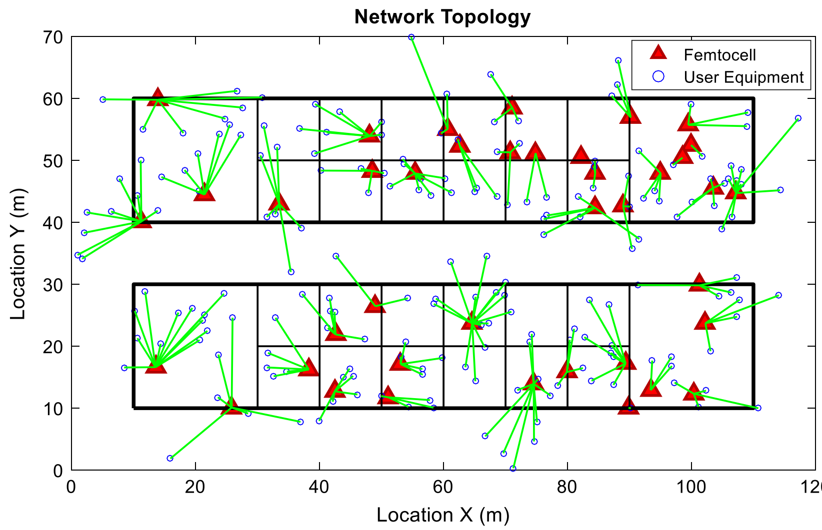

Fig. 1. The dual-strip model in [14] contains two buildings. Each has twenty 10 m × 10 m apartments. Our modified model also has two buildings, but each one consists of twelve 10 m × 10 m apartments and two 20 m × 20 m meeting halls.

interferences caused by each one [9]. In this case, the user associated to the seriously interfered femtocell may have a low signal-to-interference-plus-noise-ratio (SINR) and would hardly be able to realize a successful transmission.

A number of interference cancellation or avoidance schemes have been proposed in recent years. Game theory helps femtocells to appropriately reduce transmission power according to their user's load [10]. In [11], the authors proposed that multiuser diversity could be exploited when determining the power level on each sub-channel. Clustering femtocells together with frequency reuse was employed, in search for optimized solutions to minimize interference [12]. A spectrum sharing strategy as well as a sub-optimal power allocation method addresses the problem of interference-limited femtocells [13]. Generally, these methods can be categorized into either distributed [10,11] or centralized [12,13]. When compared with centralized algorithms, distributed ones seem more complicated and each femtocell requires higher computational capacity. Moreover, femtocells may need to frequently sense the environment and exchange local information with neighboring cells. Unfortunately, current femtocells are small, low-powered devices, and have not been equipped with the capabilities to handle the complexities of such distributed schemes. In terms of efficiency of interference mitigation strategies, we believe centralized ones prevent base stations from processing too much overhead and consequently are more feasible for small cell networks.

In this article, we propose a centralized max-throughput interference avoidance (MTIA) algorithm for Long-Term Evolution (LTE) indoor small cell networks. The primary objective of the proposed MTIA algorithm is to optimize the system throughput while avoiding potentially unacceptable interference. A simulation was implemented to compare the performance of the proposed algorithm with different schemes. The rest of this paper is organized as follows: Section 2 provides the system's model, including the network model and the problem formulation. Section 3 describes the development of our MTIA algorithm. In Section 4, the simulation results along with detailed analyses are presented. In addition, the performances of various algorithms are compared with the proposed algorithm. Finally, our conclusions are presented in Section 5.

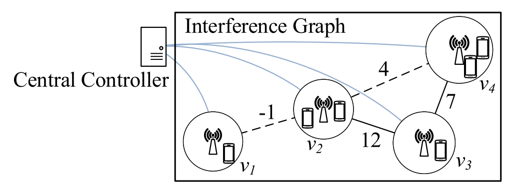

Fig. 2. Example of an interference diagram with labeled interference level on the edges. The interference threshold is 6 dB.

2. System model

2.1. Network model

In this paper, we considered a dense femtocell-overlaid LTE TDD network with the building model shown in Fig. 1, which is based on the dual-strip model described in [14]. There are two buildings, whose sizes are 20 m × 100 m, separated by a street with a width of 10 m. Each building consists of twelve 10 m × 10 m apartments and two 20 m × 20 m meeting halls. The femto-BSs are randomly distributed inside the two buildings. All of these cells are configured to be an *open subscriber group* (OSG) and operate on the same frequency band, so inter-cell interference occurs when two neighboring cells transmit simultaneously. We assumed that the system has no subcarrier allocation, so a base station only serves one user equipment (UE) in a subframe. As shown in Fig. 2, there is a central controller (CC) connected to each femto-BS in order to perform our algorithm and broadcast the scheduling decisions to all the BSs it controls. For example, the central controller will coordinate the BSs to start an interference estimation period, and make a decision after collecting the interference measurement of different cells.

We randomly distributed the UEs around the two buildings with a parameter called *indoor UE ratio*, which is the ratio of the number of indoor UEs to the number of total UEs. Each