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An Efficient Power Handling Mechanism for Interference Mitigation in a Two-Tier Cellular System

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ABSTRACT

In this paper, a two-tier cellular system is considered, where a macrocell co-exist with a femtocell network in order to improve voice and data reception in an indoor environment. In such a case, there is an interference caused by the Femtocells to the macrocell users (MU). To avoid this problem, power management techniques have been proposed to reduce the interference in a two-tier cellular system. At this point, three power schemes have been introduced. First scheme is the fixed power scheme. Second is the constant coverage Femtocell radius. Finally is the Target SINR (Signal to Interference plus Noise Ratio) scheme. A framework has been proposed which includes the three power control schemes. The schemes have been simulated using MATLAB. A comparison is carried out among the three proposed schemes.

KEYWORDS : Femtocell, Macrocell, two-tier cellular system, interference, power management techniques.

1 Introduction

In recent years, there is a tremendous growth in the field of wireless communication and the number of mobile phone users keeps on increasing. For this reason the mobile phone users face problems such as poor cellular coverage which may lead to call drops in an indoor environment. A cost effective alternative is the recent development of Femtocells. Femtocells are short-range (20-50meters) and low power base stations also called as home base station. They are installed by the customer and are connected to the internet backhaul thereby reducing the load on the macrocellnetwork[1]. Femtocells operate in an authorized band while sharing the frequency resources with the macrocell network. In such architecture, to assure a placid coexistence, efficient management of cross-tier interference is of utmost importance. In this work, a power control approach is being proposed. It has been mainly used to minimize the cross-tier interference and thereby providing a high throughput. As Femtocell base stations (FBS) will be installed in various locations, which means different demands and different impact on the overall network, hence a standard value for power transmission is likely to be unsuitable. As an alternative, adjusting the power transmission levels of Femtocell Base Stations according to the needs of the specific area would be appropriate. The transmission power of the femtocell base station is selected based upon the following three power configurations: (i) Fixed power scheme (ii) Target SINR and (iii) constant coverage Femtocell radius.

The existing literature includes interference alignment and cancellation approach[2] which handles the uplink interference that aligns the received macrocell interference as much as possible subject to minimum SIR constraints for each MU at the FBSs, by employing successive semidefinite programming (SDP) relaxations. After interference alignment, a precoding decoding scheme is used at the FBSs to minimize the mean square error of the femtocell users, which is referred as coordinated MMSE approach. For comparison purposes, a zero-forcing constraint is proposed in the minimum MSE problem in order to eliminate the remaining aligned macrocell interference separately at each FBS, which is referred as coordinated zero-forcing approach. Interference management has also been a crucial design element for multiuser systems. Judicious receiver design for interference limited systems, e.g., CDMA (code division multiple access), and multiuser MIMO (multiple input multiple output), proves useful for interference cancellation[3]. Besides multi-user detection, power control[4], and joint design of transmitters and receivers[5,6] offers interference mitigation required in interference limited systems. Antenna diversity is also an important concept in the objective of reducing bit error probability[7-10]. Power control has also been a significant issue for coexistence of two-tier networks[11,12]. A power control method is also introduced in[13], which ensure a constant femtocell radius, while a distributed power management algorithm is introduced in [14].

2 System Model

The interference between the Femtocells and macrocell users can be reduced by adjusting the Femtocell Transmission Power. The main challenge is how to adjust the Femtocell Transmission Power, so that the interference between the femtocell and neighbouring macrocell users can be avoided. To overcome this challenge, a power control algorithm has been proposed to adjust the Femtocell Transmission power so that the co-channel interference with Macrocell Users can be avoided. Here, a model framework that includes several power control methods for interference reduction has been introduced. The end user communicates through a simplegraphical interface and is asked to enter the network parameters. A typical example of the above interface is shownin Fig. 1, which exhibits the first stages of the procedure that holdnetwork parameters and topology configuration. Based on the selected power control method, the Femtocell Base Stationstransmission power is calculated with the inputs provided. Once the process stops, the figure is highlighted basedon the estimated throughput. By clicking anywhere in the map, the detailed information for the results can be obtained for anypoint of the configuration.



Fig:1 Network topology

The three power control schemes have been discussed in detail as follows:

2.1 Fixed Power Scheme

The first power control algorithm is the fixed power scheme which is the simplest of all, assigning a fixed value for every FemtocellBase Station (FBS).

2.2 Constant Radius

Thesecond method is initiated in [13], and ensures a constantcoverage femtocell radius r, by setting FemtocellBase Station's power valueequal to the power received from the MBS at a target femtocellradius r. specifically:

Where $PL_r(r)$ - path loss at the radius r
$PL_m(d)$- Macrocell path loss at distance d
P_m - MBS transmit power
G_θ - Antenna gain.
θ- the angle to the femtocell with respect to the sector angle.
G_θ Can be calculated as follows:

$$G_\theta = G_{max} - \min\left[12\left(\frac{\theta}{\beta}\right)^2, G_s\right] \quad (2)$$

where-π≤θ≤,β=70/180the angle where gain pattern is 3 dB down from peak
G_s - 20db
G_{max} – 16db, the maximum gain level.

2.3 Target SINR

The third casereadjusts the transmission power of Femtocellat regular intervals in order to achieve the target SINR value ata user-specified range when that is feasible. If $SINR_t$ and $SINR_c$ represents the target and current SINR respectively, the transmission power is given by

$$P(k+1) = \frac{SINR_c}{SINR_t} P(k) \quad (3)$$

P(k)represents the power level of FBS at the kth iteration.

3 Results and Discussions

The simulator's network configuration consists of a single macro site of radius 250 m, wherein multiple femtocell base stations are deployed in random positions. The macrocell base station is considered to be located at the middle of the site, transmitting with a predefined power value of 46dBm. The femtocell transmit power is set to 11dbm. In accordance to the urban environment model, an appropriate scheme must be considered for the simulator. Thus, the area is divided into rectangles and empty spaces, representing the buildings (walls) and the streets respectively, of a real environment.

Simulation results are given for three different power models. In the first model, Femtocell base stations are assigned a fixed value and the throughput of a macrocell user is displayed all through the entire map. And thus a fixed power scheme proves to be inappropriate, especially for the cell-edge areas with a close-by femtocell. In such a case, the received power from Macrocell Base Station is considerably minimized due to path loss, and easily gets dominated by the Femtocell Base Station transmission, even on the outside of the buildings. The situation can even get worse in case of an indoor environment as the powerreceived from the MBS decreases even further due to increased path loss added by the outer walls.

The second case is the constant radius of Femtocell Base Station coverage power scheme which proves to be better when compared to the previous case. Here the transmission power of Femtocell is adjusted with respect to the received signal power from the Macrocell Base station.

The last power control model is the target SINR scheme that provides a better throughput when compared to the above two schemes.

A comparison of the various power schemes is demonstrated in Fig. 5. The resulting throughput for anindoor macrocelluser that moves away from the femtocelland towards the Macrocell Base Station is displayed. Simulation results show the pros and cons of each method, and concluded on the suitability for different network situations.

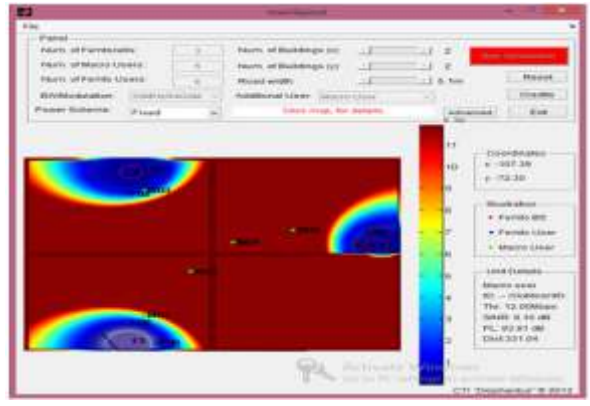

Fig:2 Throughput of a macrocell user for fixed power scheme

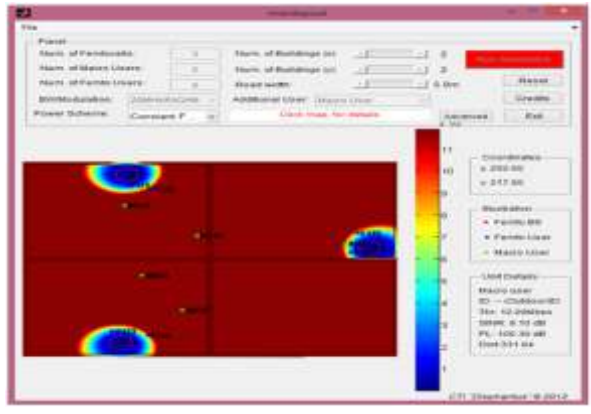

Fig:3 Throughput of a macrocell user for constant femtocell radius power

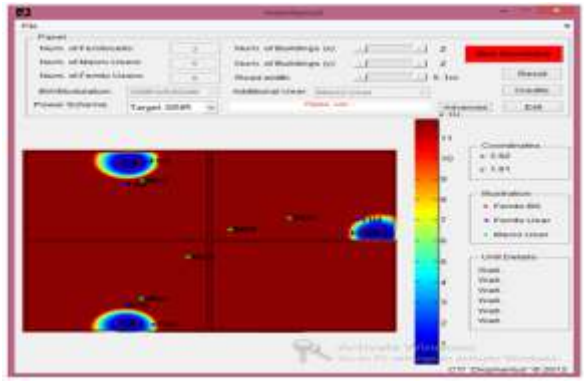

Fig:4 Throughput of a macrocell user for target SINR

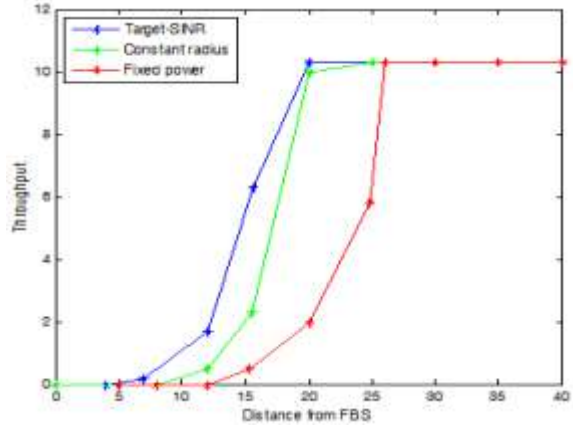

Fig:5 Throughput of the macrocell user for three different power configurations

4. Conclusion

In this work, a framework with powercontrols capabilities has been proposed over fully customized co-channel Femtocellsdeployments. The three power schemes have been compared and concluded that the power management techniques achieves up to 17 times better throughput than the fixedpower scheme.

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