A DISTRIBUTED ENERGY-EFFICIENT IN FEMTOCELLS WORKS AND POWER MANAGEMENT

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ABSTRACT:

Energy Efficiency has become a critical metric in the current wireless communication and network because the energy spent for operating the networks is more. In particular, the base station is the most energy consuming part of a mobile network. This proposes an energy efficient Femtocells Power management scheme for enterprise environment. In order to achieve Power saving, this use the sleep mode and early handover of Femtocells and propose two stages femtocell Power management scheme based on self-configured Power setting and self-optimized Power setting. The maximization of energy efficiency of downlink OFDMA macro-femto networks. Both the transmit Power constraint of femto base stations and the SINR thresholds of femto users and macro users are considered. To decrease the computational complexity joint subchannel and Power allocation are decomposed into two steps and a distributed resource allocation scheme is proposed to resolve the resource allocation problem.

Keywords:

[1] INTRODUCTION

Achieving high energy efficiency has become a critical topic in the current wireless communication and network because we spend a number of energy for operating networks. In particular, the base station is the most energy consuming part of a mobile network. As
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mentioned that the base stations in the third generation (3G) mobile network spend about 57%, mobile switching is about 20%, core transmission part is about 15% and data centre is about 6%. Small cell networks such as Wi-Fi is not different from 3G mobile network in this matter. As said that Wi-Fi laptop access are only 1-2% efficient when we compare radiated Power to total required Power. Therefore, We should not ignore energy efficiency when designing a femtocell network and try to save the total Power of femtocell network in this paper.

Recently, with the exponential growth of mobile data traffic, wireless communication networks will cause a significant operational expense (OPEX) for mobile operators, leading to a great increase in the total Power consumption. Based on this background, the concept of Green Communication is proposed to develop environment friendly and energy-efficient technologies for future wireless communications. Therefore, pursuing high system energy efficiency is a trend for the next generation wireless communication.

On the other hand, the rapid growth of demand for wireless data has encouraged the development of femtocell technology. A femtocell base station (FBS) is low-Power, low-cost and has a much smaller coverage than macro base stations (MBSs). By reducing the distance between wireless base stations and end users, femtocell technology can increase the data rate and provide better indoor coverage. FBSs operate in licensed spectrum as macro base stations do and use broadband internet access as backhaul. Femtocells can reuse the same channel simultaneously if they are far from each other, which will improve the spatial spectrum efficiency and the whole capacity of the network.

However, as mentioned above, energy-efficiency is attracting more and more attention. FBSs while meeting the signal-to-interference-plus-noise ratio (SINR) requirement of macro users. The downlink Power control is formulated as a nonlinear optimization problem for energy efficiency maximization and a sub-optimal solution named EEPC is obtained with the information on the gradient of allocated Power and the total system Power exchanged between MBS and FBSs. In [1], an energy-efficient power control scheme for interference-limited two-tier femtocell networks is introduced. A cellular link protection algorithm is also proposed to guarantee the performance of macro users. However, in [2] [4], although they both consider Power control strategy, subchannel allocation scheme is not considered. Moreover, the performance of femto users is neglected, either. In [2], the maximization of energy efficiency of downlink OFDMA femtocell networks is investigated. Both subchannel and Power allocation are considered. However, the authors only consider transmit Power as the only constraint and femtocells are deployed with dedicated subchannels, which is unrealistic and spectrum inefficient.

In this paper, We study the energy-efficient resource allocation for the downlink scenario in co-channel macro-femto networks. Subchannel allocation and Power allocation are both discussed considering not only the Power constraint but also the SINR constraints of FUEs and MUEs. We model the subchannel and Power allocation problem as a non-cooperative game, aiming at maximizing the energy-efficiency of FBSs, we both the transmit Power and circuit Power are considered. In order to mitigate interference from FBSs to other femto users and macro users, a price function is introduced to depress aggressive behaviors. For
decreasing the complexity, We decompose the resource allocation problem into two sub-problems. A distributed subchannel and Power allocation scheme is proposed. Simulation results show that the proposed algorithm has a better performance in terms of energy efficiency.

The rest of the paper is organized as follows. We first introduce the system model and formulate the problem in Section. This then discuss the non-cooperative game and decompose the joint subchannel allocation and Power control problem into two steps in Section. Nash equilibrium is also analyzed in this section. In this Section, the performance of proposed algorithm is analyzed by computer simulations.

Femtocells have become an important technology to improve the performance of the current wireless communication and network. This can define the femtocell as consumer installed wireless data access point inside homes or offices. The backhaul of the femtocell becomes a broadband access (Asymmetric Digital Subscriber Line (ADSL), cable, etc.) and it connects to the cellular operator network through internet [3]. The advantages of the femtocell are that it brings higher throughput and area spectral efficiency. According to [4] and [5], area spectral efficiency of Long Term Evolution (LTE) without femtocell is 16.32 bps/Hz/cell but LTE including femtocell can be improved by 10% as 18 bps/Hz/cell. In addition, downlink throughput in mixed macrocell and femtocell deployment with interference management can be improved by 205% in cell edge and 250% at cell medium. If interference management technique is not used, the improvement is about 10%. This result shows us how interference management technique is important in macrocell and femtocell deployment. Secondly, it is a low cost solution because we use the exiting resource such as ADSL or cable. Thirdly, it has a better cell coverage and can extend a handset battery life. On the other hand, the disadvantages are that it brings a higher cross-tier interferences among different kinds of cells and intra-tier interferences among same kinds of cells. Secondly, it can produce a harmful effect on a subscriber who uses a broadband service because they share one broadband access line. Especially, the interference problem becomes more serious because a number of femtocell base stations will be deployed without planning in the macrocell and also their Power level is imbalance.

Traditionally, the interference mitigation techniques are classified into three categories which are coordination, cancellation or suppression, and avoidance. The interference coordination is a way to maximize signal to interference and noise ratio (SINR) by a coordinator. Based on one policy, the coordinator allocates radio resources to users in order to avoid conflict between the interfering signals and the desired signals. Therefore, this technique is highly related to resource allocation and scheduling. Interference cancellation is a way to remove interfering signals from the desired signals. The receiver estimates the interfering signal using minimum mean squared estimation (MMSE) or maximum likelihood sequence estimation (MLSE) and then subtracts it from the desired signal. The interference avoidance is based on finding channel use and avoiding the interfering signal. This technique mainly checks and uses the resource availability. Thus, it often means interference coordination. In addition, Power management can be classed as interference mitigation.
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technique. It can be defined to adjust the transmission Power of wireless communication systems in order to save Power.

[2] SYSTEM MODEL AND PROBLEM FORMULATION

In this section, We first introduce the scenario We consider in this work and then We formulate the resource allocation problem.

A. System Model

The consider a downlink of two-tier co-channel macro-femto network depicted in Fig. 1. It consists of \( N \) MBSs denoted by \( \{M_i\}_{i=1}^{N} \), and \( K \) randomly distributed FBSs in each MBS denoted by \( \{F_i\}_{i=1}^{K} \). All femtocells are assumed in closed access mode, i.e., only FUEs authorized by the FBS can have access to that FBS. A total number of \( m_0 \) MUEs are randomly deployed in each macro cell. Let \( \{f_{i,j}\}_{j=1}^{N_{Fi}} \) represent FUE \( j \) belonging to FBS \( i \), \( \sum_{i=1}^{N} N_{Fi} \) is the total number of FUEs in FBS \( i \). The total amount of bandwidth of the system is \( W \) and the total number of subchannels is \( L \), thus the bandwidth for each subchannel is \( \frac{W}{L} \) (denoted by \( \omega \)). It is assumed that during each time slot, the same subchannel can be occupied by only one active FUE in each FBS or one active MUE in MBS, to avoid intra-cell interference.

II. PROBLEM FORMULATION

Power management problem to save energy can be defined by "Set cover problem" which is Well known NP-complete problem and does not consider capacity, user traffic, the required SINR, etc.

In this problem formulation, We include the sleep mode of a femtocell as one objective. Maximizing So state means maximizing the sleep mode of the femtocell and minimizing the
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The total transmit Power. This optimization problem is decomposed into two separate parts for the sake of saving energy. Therefore, the solution of this problem should be satisfying both minimum each subscriber Power (P user capacity) and maximum So state (which means minimizing PjLXed radio through sleep mode). We will design the femtocell Power management through early handover or cell coverage extension as shown in figure 1.

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The details of each step are as follows:

Step 1: Calculate femtocell radius (RF)

The femtocell radius can be calculated by pathloss model as follow:
\[ L = 10 \cdot \log_{10} \frac{d}{R_F} + C (\text{dB}) \]

where \( n \) and \( C \) denote the path loss exponent which represents how quickly the signal attenuates and the path loss at a reference distance of \( d = 1 \text{ m} \), respectively. Therefore, We can calculate the femtocell radius (RF) after measuring the path loss.

Step 2: Select candidates having handover possibility.

Basically, the frequent handover rate of a cellular system brings a lower mobility and it is important factor in wireless system supporting mobility. However, We assume a femtocell has a low mobility environment and design handover policy for maximizing So state. At first, We define the early handover area (At) which means handover possibility area for Power saving and the candidates having handover possibility (S\( \diamond \)) of the femtocell. Secondly, We decide the area based on femtocell radius (RF) and it is a part of each femtocell edge area (At c D.k). The area will be able to be found by numerical analysis.

If all users and guests are located in handover possibility area, the femtocell is the highest candidate to become So. If some users or guests are located in centre of the femtocell, the cell is the lowest candidate.

Step 3: Decide whether or not a femtocell goes in the sleep mode.

Based on the candidates in step 2, We can decide whether or not a femtocell goes in the sleep mode. If all subscribers are situated in handover possibility area.

This decide the femtocell base station goes into the sleep mode and subscribers are connected to neighbor femtocell base station. If some subscribers are located in handover
possibility area but some subscribers are located nearby handover possibility area, to keep an eye on them and check whether or not the handover possibility area can be extended.

Step 4: Carryout handover and adjust each subscriber Powers of the femtocell base station.

Interference caused by FBSs in other macro cells is ignored due to the long distance between the receiver and the interfering transmitters, the low transmit Power of FBSs and penetration loss of walls. We assume MBS allocates its transmit Power equally on each subchannel.

Let \( m_i \) denote macro user \( i \) occupying \( l \)-th subchannel. We define \( p_{Mm}^l \) as the transmit Power of MBS \( m \) on subchannel \( l \) and \( p_{Fk}^l \) as the transmit Power of FBS \( k \) on subchannel \( l \), respectively. Let \( g_{Mm,mi}^l \) denote the channel gain from transmitting MBS \( M_m (m \leq N) \) to the receiving macro user \( i \), \( g_{Fk,mi}^l \) denote the channel gain from transmitting FBS \( F_k (k \leq K) \) to the receiving macro user \( i \), respectively.

[3] ALGORITHM PROPOSED

Resource allocation

Foreach FBS:

Step1. Subchannel allocation.
(1) Allocate Power equally to each subchannel.
(2) Allocate subchannel to FUEs.

Step2. Power allocation.

[4] CONCLUSION

In this paper, We have proposed energy efficient femtocell Power management scheme for enterprise environment. The proposed scheme has two stages Power management which are initial self-configured Power setting and self-optimized Power setting. In the first stage, the initial Power is based on the strongest receiving Power from macrocell. The second stage is composed of 4 steps. The first step is to calculate femtocell radius. The second step is to select candidates having handover possibility. The third step is to decide whether or not a femtocell goes in the sleep mode. The fourth step is to carry out handover and adjust each subscriber Powers of the femtocell base station.

This femtocell Power management scheme is based on the sleep mode and early handover of femtocell. The sleep mode of macrocell base station is one of high impact techniques. The sleep mode of macrocell base station can be used according to difference between day time and night time of radio resource usage. It brings the Power saving about 30% and 55% for 3G and 2G system, respectively. How ever, the sleep mode of femtocell base station in this paper.
has been designed regardless of day time and night time radio resource usage. The number of femtocell user is usually small as 1-5 users.

This can extend some neighbour femtocell coverage, cover a subscriber in neighbor femtocell, and allow some femtocell base station to go in the sleep mode. In the section IV, the performance for the sleep mode of the femtocell base station has been investigated. We can observe Power saving when femtocell has small number of users. When each femtocell has 1 user, 2 users and 3 users, We achieved about 35%, 20% and 6% Power saving, respectively. If each femtocell has more than 4 users, We could not obtain Power saving because it would be difficult that a femtocell goes in the sleep mode.

The energy efficiency of Femtocells in the downlink OFDMA two-tier heterogeneous networks and both subchannel and Power allocation are studied. We consider not only the transmit Power constraint of FBSs but also the SINR thresholds for both macro users and femto users. The Powerallocation problem is formulated as a non-cooperative game and a price function is introduced to decrease the interference. Based on that, a distributed subchannel and Power allocation scheme is proposed. Simulation results show that compared with equal allocation of transmit Power on each subchannel and the algorithm in [10], our scheme can reach a higher energy efficiency while maintaining a relatively high SINR performance.

The exponential growth of mobile data traffics, wireless communication networks will cause a significant operational expense (OPEX) for mobile operators, leading to a great increase in the total Power consumption . Based on this background, the concept of Green Communication is proposed to develop environment friendly and energy-efficient technologies for future wireless communications. Therefore, pursuing high system energy efficiency is a trend for the next generation wireless communication.

REFERENCES


