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Interference Cancellation in Heterocell Configuration using Channel Allocation Mechanism

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Abstract—Femtocell networks, consisting of a conventional macro cellular deployment and overlaying femtocells, forming a hierarchical cell structure, constitute an attractive solution to improving the macrocell capacity and coverage. This paper treats the uplink interference problem in orthogonal frequency-division multiple-access (OFDMA)-based femtocell networks with partial cochannel deployment. First propose an inter-tier interference mitigation strategy without the femtocell users power control by forcing the femto-interfering macrocell users to use only some dedicated subcarriers. Then propose subcarrier allocation schemes for macrocell users and femtocell users, respectively, to independently mitigate the intra-tier interference. The proposed interference mitigation scheme for femtocell networks offers significant performance improvement over the existing methods by substantially reducing the inter- and intra-tier inferences in the system, and try to make High Quality Packet Sending in shortest time.

Index Terms— Femtocell, OFDMA, interference mitigation

I. Introduction

In recent years, wireless operators have been experiencing a steadily increasing demand for higher data rates and better quality of service due to the constant growth in the number of active wireless terminals. One significant challenge in wireless communication is how to improve the coverage . Studies in wireless usage show how that over 50% of all voice calls and more than 70% of data traffic originate from indoors [1]. Therefore, indoor coverage providing high data rate and quality-of-service (QoS) is a key issue in developing next-generation wireless systems. However , adding more number of mobile users inside the macro cell or macro cell base station (MBS) to meet the growing indoor service demands is very expensive and macrocell consumes more power. To avoid this problem, additionally need the microcell or directional antennas. If directional antennas are used in macrocell provides better quality but it does not solve the problem of indoor coverage and RF interference arrised because same bandwidth may be used in both antennas. Main drawback of installing directional antenna is cost of deployment. In some other cases microcells are deployed in macrocell provides better system capacity gain and it was completely operator control. The shortcomings of the microcell is very expensive to installation and little difficult to maintenance of the cell tower.The microcell does not solve the inddor coverage problem. Instead, femtocell access points (FAPs) have been proposed as a new system architecture to tackle this problem [6], [7]. An FAP is a simple, low-power and low-cost base station which is installed at the house, office, warehouse, etc.,that provides local access to the network by means of some cellular technology (e.g., 2G, 3G).The femtocell provides more advantages. If installing the femtocell inside the macrocell, provides better coverage and prolonged handset battery and capacity gain from the higher SINR and dedicated BS to home subscriber. It reduces the power consumption because the users are near to the femtocell. So it takes less Radio Frequency (RF) power to provide a high bandwidth connection. Using femtocells benefits both users and operators. By using femtocell to improve the overall performance of the macrocell, energy efficiency, QoS and reduced subscriber churn.

If including femtocells within the macrocell it solves the indoor coverage problem but it brings about multiple new challenges in terms of network architecture, interference management and synchronization [6]. In particular, the interference problem becomes a major issue in wireless communication that requires new solutions due to the extra degrees of complexity in comparison with standard cellular networks. There are basically three types of deployment configurations for femtocell networks [4]. The first one is orthogonal deployment, where the spectrum is divided into two independent fragments: one used by the macrocells and the other used by the femtocells [4]. Although this approach can eliminate inter-tier interference, frequency resources are not efficiently utilized. The second is cochannel deployment, in which both macrocells and femtocells have access to all available channels [5]. Such a scheme could generate an excessive levels of interference. The third one is a partial cochannel deployment method, where the whole spectrum is divided into two parts, one dedicated to the macrocells and the other shared by macrocells and femtocells [6]. In the literature mainly focus on solutions for cochannel assignment and closed access by using power control. Uplink power control for the femtocell users (FUs) is discussed in [5],[9]. A distributed channel assignment algorithm for mitigating interference among femtocells without considering the interference from FUs to the MBS. The most of the wireless network uses CDMA based network because of low cost. The CDMA (Code Division Multiple Access) improves the sound quality of the network and it takes low transmit power so user talk time may be longer. But in the CDMA based network has some problem, that is coverage optimization because the CDMA coverage can expand or shrink. That is called as breathing. And cell broken may be happened. If User located some distance from base station (BS) must be running out of transmit power (maximum already) that can result in broken cell. The CDMA based network is discussed in [10].The previous work is based on the auction algorithm for mitigating the interference discussed in[3].This algorithm is implemented in both the macrocell and femtocell. The Auction algorithm has low complexity and suited for parallel implementation. But it needs more constraints for subcarrier allocation for macrocell and way of finding optimal solution. This paper focus on the uplink interference mitigation in the OFDMA femtocell network that employs the partial cochannel

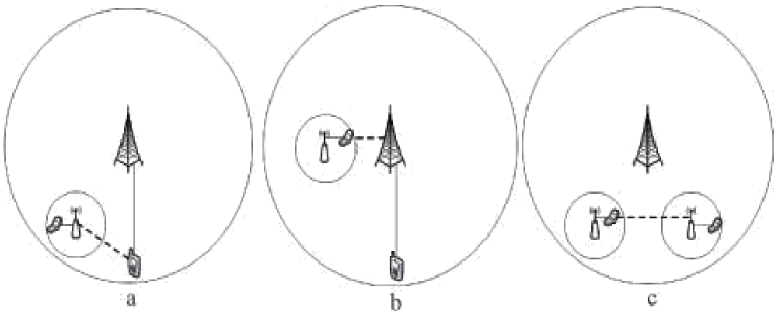

Fig 1. (a) MU to FAP interference. (b) FU to MBS interference. (c) FU to FAP interference

deployment strategy.First the inter-tier interference mitigation method is proposed according to the relative positions of the macrocell users (MUs) and FAPs. The macrocell user is classified as “femto-interfering users” that can use only some dedicated subcarriers, and “regular users” that can use both dedicated subcarrier and shared subcarrier which are also used by the femtocell users. Secondly an intra-tier interference mitigation is developed by using localized algorithm to optimize the subcarrier assignment for both the macrocell and femtocell. As a result, the interference among both the macrocell and femtocell is mitigated, and improve the throughput of the whole network.

II. Interference In Femtocell Network

In a standard cellular system using OFDMA-based network access.The OFDMA involves assigning orthogonal (non-overlapping) subcarriers among different users is an effective to handle multipath fading with low complexity. Both inter- and intra-cell interference are avoided by frequency allocation. Each subcarrier should be allocated to only a single user within the cell (or sector) so that intra-Cell interference is avoided. Moreover, users from adjacent cells (or sectors) might cause interference to the users in the cell of interest so frequency allocation has to be optimized to minimize the inter-cell interference. Assume that a femtocell network has a single MBS, then one can expect to encounter three types of uplink interference: MU to FAP interference, FU to MBS interference, and FU to FAP interference, as illustrated in Fig. 1.

A. MU to FAP Interference

At any time, a given MU is transmitting enough power to achieve a minimum signal-to-interference plus noise ratio (SINR) at the MBS. SINR used to measure the quality of wireless Communication which is defined by path loss. SINR at the MBS receiver given the current channel condition, which is measured by the system periodically. If an macrocell user more away from the Base Station, it takes large amount of power to transmit the data. The power should meet the target SINR value. As depicted in Fig. 1(a), if an MU happens to be in the vicinity of a femtocell and also far away from the MBS, then its signal could be high enough to propagate through the walls of the building here the FAP is deployed and generate interference. This will happen only if the FU in the femtocell uses the same frequency as the MU. It is important to note that, as stated in [7], it is indeed on the macrocell edge where femtocells are most necessary and useful, so this kind of interference is expected to be very frequent.

B.FU to MBS Interference

Due to the frequency reuse among femtocells, it is possible that many FUs in different femtocells use the same subcarrier as an MU, thus they will interfere with the macrocell, as depicted in Fig. 1(b). In order to overcome the interference from FUs to the MBS, to determine that it needs to transmit higher power in order to reach its target SINR at the receiver. This increase of the transmission power will worsen even more the MU to FAP interference problem described above.

C. Femtocell to Femtocell Interference

A femtocell is, by definition, located indoors, so interference occurs when adjacent femtocells use the same subcarriers. The interference level between non-adjacent femtocells is negligible, because any signal coming from one FU travels through at least two walls to reach the FAP of a non-adjacent femtocell. Therefore, the frequency allocation strategy should not allocate the same subcarriers in adjacent femtocells in order to avoid the intra-tier interference among femtocells.

III. Inter-Tier Interference Mitigation

An example of femtocells and macrocell coexistence in a two-tier network is illustrated in Fig. 2. The femtocells overlay on top of the macrocell forming a hierarchical cell structure. At distances D1 and D2 respectively from MBS, 25 surrounding femtocells are arranged in a square grid (e.g., residential neighborhood) of area D^2 = $10000m^2$, with 5 femtocells per dimension. The radius of each femtocell is R^{FC} = 10m. The FAPs are located in the center of their corresponding femtocells. The coverage dius of the macrocell is R^{MC} = 500m. We assume that the inter-macrocell interference is mitigated through fractional frequency reuse (FFR). Therefore we focus on inter-tier interference mitigation under a single macrocell scenario.

Based on the fact that there are much less number of FUs in each femtocell than the number of MUs in each macrocell, a portion of the whole spectrum would be sufficient for femtocells in most cases. Furthermore, in order to avoid performance degradation due to interference, it may be better to limit the spectrum. Therefore, it is reasonable to adopt the partial cochannel deployment strategy and to implement spectrum reuse among femtocells by means of subcarriers allocation. Given a total number of available subcarriers N , we assume that N_S subcarriers are shared by the FU and MUs, whereas the remaining ($N - N_S$) subcarriers are used by MUs only. The transmitting power of MU is denoted as PMU and P^{MU}_{min} by using power control according to the measurement of each subcarrier channel state. Owing to the small radius of the femtocell and FU and MU being the same type of terminal, assume that the transmission power of FU, PFU, is constant and PFU= $P^{MU}_{min.}$ It is shown that such constant power assignment on subcarrier will not bring noticeable rate decline compared to the mercury water-filling (MWF) power control algorithm.

A. Inter-tier Interference Mitigation Strategy

In this subsection we propose a cochannel interference mitigation strategy between MUs and FUs over the shared subcarriers. We address the uplink interference problem by considering the QoS requirements for both MU and FU in term of SINR. As for mitigating the interference from FUs to the MBS, the MU first uses power control to improve the SINR in order to satisfy its QoS requirement. If the MU cannot reach its minimum SINR requirement due to the long distance from the MBS and the interference from FUs, it should switch to the dedicated subcarriers. If the MU can meet its target SINR, then it will be checked whether or not its transmission power is strong enough to interfere with its nearest cochannel FU. If the position of the MU is close enough to an FAP to interfere with the cochannel FU, it should use the dedicated subcarriers. The proposed strategy for eliminating the inter-tier interference (i.e., MU to FAP and FU to MBS) is summarized as follows.

- For any given MU m , estimate the total path loss to the MBS (XMUm) and estimate the path loss to its closest active FAP (XMFm) by measuring the reference signal received power(RSRP) of the active FAPs in the downlink.
- Check whether the MU can meet its target SINR by using power control. If yes, consider the worst interference case from this MU to its nearest FAP, Where the nearest FAP, Where the FU is on the edge of this FAP. Then the MU estimates whether or not its

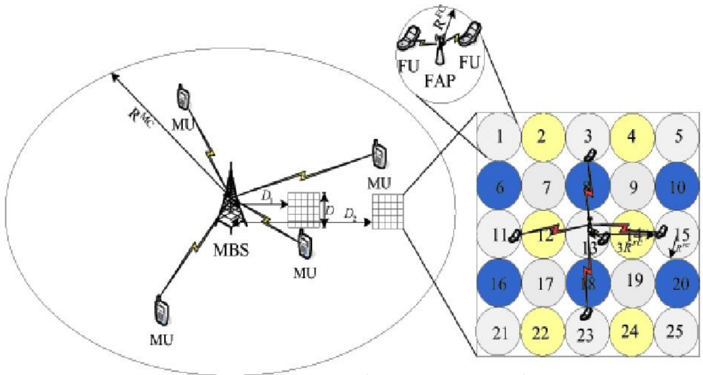

Fig. 2. A two-tier network of macrocell and femtocells.

transmission power causes the FU's SINR below the minimum requirement. Here, the reason for considering the worst case scenario is to maintain the uplink coverage of the femtocell.

- If both the MU and the FUs in its closest femtocell can satisfy their SINR requirements, the MU is a regular user and can use either the shared subcarrier or the dedicated subcarrier. Otherwise the MU is a femto interfering user and can only use the dedicated subcarrier.

After the above strategy is applied, all MUs within the macrocell are classified as either "regular users" or "femto interfering user". Such as the macrocell radius, femtocell radius, penetration loss through the building wall, transmission power of an FU, etc.

IV. Intra-Tier Interference Mitigation Via Localized Based Subcarrier Allocation

As discussed in the previous section, the cochannel interference from FUs to MBS is avoided by using uplink power control on MUs. Based on the power control results, all MUs are classified as "regular users" and "femto-interfering users". By allocating only dedicated subcarriers to femto-interfering users, inter-tier interference is mitigated and both the MUs and can meet their target signal to interference plus noise ratio(SINR) requirements if the intra-tier interference can also be eliminated, which can be achieved by independently allocating subcarriers for macrocells and femtocells, as discussed in this section. In this architecture, the resource allocated to the both femtocell and macrocell. The resource allocation for macrocell network is illustrated in Algorithm1.After the allocation of the subcarrier the path was identified between the source and destination and calculates the path loss. The resource allocation will find the nearest tower to the mobile. Then find the nearest tower to that. The main advantage of finding this is to use the available bandwidth. And connect the mobile to the nearest tower. And by this way maintain good band width usage. In localized approach, to request and process data only locally and only from nodes who are likely to contribute to rapid formation of the final solution. The approach enables two types of optimization: The first, guarantees the fraction of nodes that are contacted while optimizing for solution quality. The second provides guarantees on solution quality while minimizing the number of nodes that are contacted and/or amount of communication. This localized optimization approach is applied to two fundamental problems in the sensor networks. The subcarrier allocation for macrocell is described in algorithm1. By this way the intra-cell interference is avoided. The architecture of the system is described in fig 3.The femtocell subcarrier allocation is similar to the macrocell subcarrier allocation.

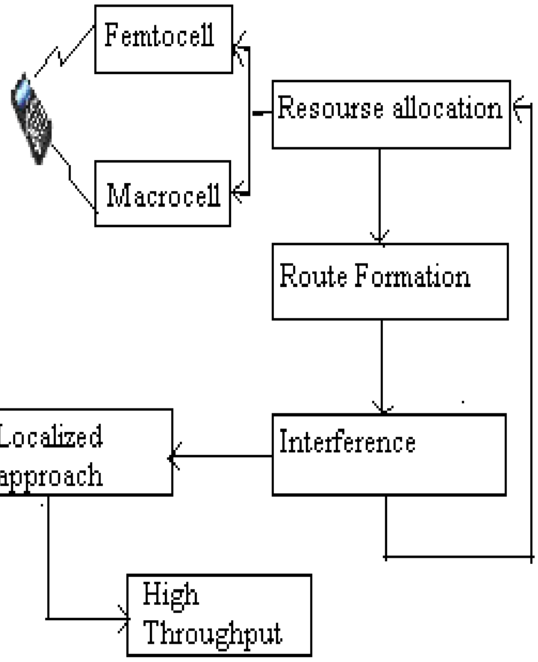

Fig 3. System Architecture

In that each femtocell considered as a single cell. First consider the femtocell subcarrier allocation, where an each femtocell act as independently and implements the localization algorithm for subcarrier allocation. But different femtocells run asynchronously. Assume the subcarrier allocation is updated in each iteration. Consider one subcarrier is allocated for a femtocell, that is also shared by the adjacent femtocell means that the SINR value will be worse than the subcarrier occupied by the femtocell.As a result the subcarrier is already used in the femtocell are not to be allocated for another femtocell.

By using localized algorithm to solve the interference between the femtocell. The localized algorithm is

Algorithm1: The Localized approach for macrocell subcarrier allocation

1. **Initialization:** Search and select the set of all subuser as unhappy except for dummy subusers. Every subuser estimate its location.
2. **Request :** Each subuser sent request to its neighbors and get the information from the neighbors.
3. **Repeat:**
   a) Choose the subcarrier and allocate to the users in macrocell.
   b) If this subcarrier is already been allocated to another femto-interfering user, remove that allocation from the macrocell.
   c)Update the subcarrier location, and find the path between to the terminal node
4. **Until** all femto interfering subusers are happy.
5. Allocate the remaining subcarriers to the regular unhappy subusers following steps 3-4. Until all regular subusers are happy.
6. Allocate remaining subcarriers randomly to the remaining dummy subusers.

Algorithm2: The Localized approach for multi-femtocell subcarrier allocation

1. **Initialization:** Obtain the set of subcarier for each femtocell
2. **Run** the localized approach to perform subcarrier allocation for every single femtocell.
3. **Repeat**
   a) Collect the subcarrier allocation results for each user in femtocell, and find the conflicting subcarrier
   b) If conflicting arrised,it causes the interference, drop or remove that subcarrier from the users in the femtocell and allocate the new subcarrier in femtocell which is near to the user.
   c) The updation of subcarrier allocation results are sent to the FAP.
4. **Until** all subcarriers are allocated to the user by step3

independently performed for resource allocation in every femtocell ignoring the constraint that each user and its corresponding virtual user must share the same resources. To allocating a subcarrier in a cell to any of its users is acquired based on the channel state measurementand network sniffer capability. To mitigate the interference between femtocell is explained in Algorithm2.

Fig 4.Hetero cell configuration

Fig 5.Interference Occurred

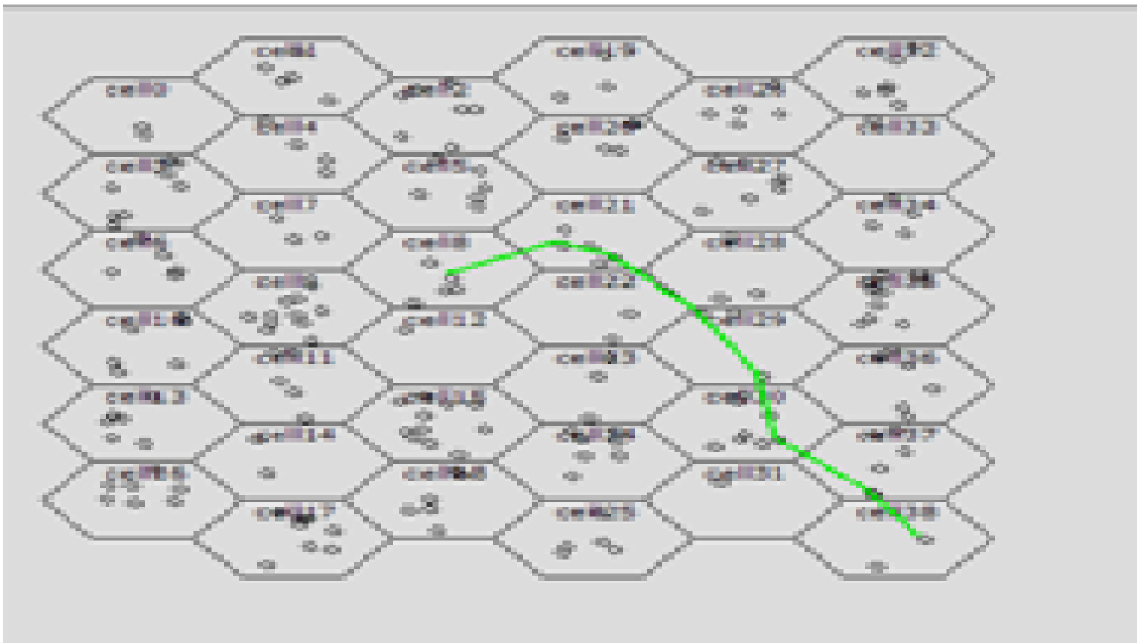

Fig. 6 Example of an image with acceptable resolution

Fig 7.Result Analysis

V.Conclusion

In this paper, we have proposed interference mitigation strategies for OFDMA based femtocell networks,consisting of a conventional macro cellular deployment and overlaying femtocells and treats the uplink intereference. First propose an inter-tier interference mitigation strategy without the femtocell users power control by forcing the femto-interfering macrocell users to use only some dedicated subcarriers. Then propose subcarrier allocation schemes for macrocell users and femtocell users respectively, to independently mitigate the intra-tier interference. The proposed interference mitigation scheme for femtocell networks offers significant performance improvement over the existing methods by substantially reducing the inter and intra-tier inferences in the system, and try to make High Quality Packet Sending in shortest time.

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