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INTERFERENCE CONTROL AND RADIO RESOURCE MANAGEMENT IN FEMTOCELL

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VISHAL L.SHINDE
Department of Electronics and Telecommunication Engineering,
Vishwabharati Academy College of Engineering, Savitribai Phule Pune University,
Ahmednagar- 414201[MS],India. shinde.vishal20@gmail.com

DR.A.K. KURESHI
Department of Electronics and Telecommunication Engineering,
Vishwabharati Academy College of Engineering, Savitribai Phule Pune University,
Ahmednagar- 414201[MS],India. akkureshi@rediffmail.com

ABSTRACT:

Recently advancement in 4th generation (4G) heterogeneous networking has opened the door for the deployment of femtocells in a large scale. The deployment of femtocells in the existing macrocell networks and in 4G networks will significantly increase due to femtocells offer increase the coverage, the capacity and user friendly mode of operations in the both home and office environments. So, these low power home-based access points are going to change the landscape of the mobile technology, and the network business in the coming years.The objective of project is to study and propose the different logical indoor femtocells architectures for the LTE (long term evolution) - advanced, and examine for the impact of these different femtocell architecture changes on the service delivery to end users.

Growing demands for the B.W hungry data services on wireless cellular networks have been a great impetus to the development of new ways of improving system capacity. The significantly capacity improvement can be achieved the femtocells enhanced spatial reuse on the spectrum resources. Further improvement can be combining in femtocell technology with the orthogonal frequency-division multiple access (OFDMA) technology.

KEYWORD: Femtocell, interference avoidance, orthogonal Frequency-division multiple access (OFDMA), resource allocation, resource reuse.

INTRODUCTION:

Mobile applications required high-quality communications have tremendously increased in recent years. The femtocell network has widely studied as a promising candidate in the next-generation wireless system to improve the radio resource reuse efficiency and femtocell base stations can be deployed to cover dead zones or to share traffic loads from macrocells. Using Femtocell, the large amount of traffic being properly handled. The coverage and capacity of macrocells can be enhanced in cellular networks.

Moreover, certain study and show that deployment of macrocells can be reduced since 70–80% of traffic can be offloaded from macrocell. Instead of deploying the more macrocells, the deployment of femtocells is an economical option due to its low cost as well as low power consumption. Which is based on the Third- Generation Partnership Project (3GPP) specifications, the femto architecture is composed of multiple sets of femtocell user equipment (FUEs), femtocells, and a femtocell management system (FMS). The FUEs, e.g., mobile devices or laptops, connect to its associated femtocells through air interface. Femtocells can be deploying in houses and enterprise buildings, or public places. Femtocells with geographical proximity are logically grouped as well as connected to the Internet through the same FMS via broadband wire-line connections.

The Femtocells are design to deploy by the end users with minimum intervention from the service providers, the femtocell deployment is not well controlled and Numerous Femtocells may be randomly distributed in a surrounding area. The coverage of neighboring femtocells overlapping and their FUEs may interfere with one another. The femtocell interference occurs when the radio resources with the same frequency and that time slot are allocated to overlapping FUEs [6], [7]. Different two categories of femtocell interference specified by the network tier or the frequency. The first category is specified as co-tiered and cross-tiered interference in the tiered network [8], [9]. In the co-tiered interference and the source node and the interfered node are in the same network tier. For example, a femtocell is tobe disturbed by the unwanted signals sent from other femtocells so when a larger number of neighbors are densely deployed, severe co-tiered interference arises more often and is difficult to manage [6], [10]–[12]. The deployment of femtocells in an urban area typically leads to the overlapping of coverage areas, multiple neighboring femtocells [6]. For example, the deployments are similar to the adjacent houses or blocks of apartments [4]. In cross-tiered interference, the source and the victim belong to more network tiers. The problem of cross-tiered interference has widely studied through techniques of spectrum allocation [7], [9], [13]–[18], power adjustment [18], [19], and open versus closed access operation. The cross-tiered interference is independent of co-tiered interference. Since the mitigation of the co-tiered interference required adaptive techniques, we focus on the control of the co-tiered interference in this paper.

The other category is specified as co-channel and adjacent channel interference. In co-channel interference, the same time–frequency resources are occupied by two different transmitters. For the adjacent-channel interference, the different but insufficiently separated resources are reused. With the co-channel deployments, the femtocells are expected to reuse resources to improve system capacities and the spectral utilization [23]. However, the same resources can be reused by closely deployed femtocells, and it causes low communication quality [10]– [12]. With co-channel interference, femtocells lose the original advantages of resource reuse. Since a flexible resource assignment technique alleviates co-channel interference, the orthogonal frequency-division multiple access (OFDMA), intensely considered by 3GPP LTE (long-term evolution), is considered in this paper. In addition, since OFDMA reduces the interference from the adjacent cells operating in the same frequency by assigning sets of orthogonal frequencies in different cells, the effect of adjacent-channel interference can be ignored [6]. The OFDMA exploits multiuser diversity by assigning resources according to the channel qualities of FUE's. The smallest unit of resource may be assigned is called a PRB (physical resource block) based on OFDMA. One resource frame has 20 time slots and where the frame length is 10 ms. To enable the femtocell technology, this work aims to propose a resource allocation strategy to copy with the interference and improve PRB efficiency in OFDMA femtocell networks.

RELATED WORK:

In LTE network, the indoor access networks are supported by deployment of femtocells. Femtocells are designed to be deployed by user demand, the co-channel as well as co-tiered interference problems are severe. To mitigate the effects of the co-channel and co-tiered interference, Junetal. proposed inter-cell interference cancellation techniques. Jun and Andrews [25] proposed the inter-cell interference cancellation techniques, but the approach is often disregarded due to errors in the cancellation process [26]. Moreover, the sectorized antenna and multiple radio paths have also been suggested by Chandrasekhar and Andrews [8]. This approach reduces the possibility of neighboring interference, and beam forming is also one of the effective techniques. In addition, Claussen and Pivit introduced a dynamic selection of predefined antenna patterns and to reduce the unwanted power leakage. Preceding hardware based approaches usually increase hardware cost. In contrast, the power control algorithms and radio resource management serve as cost effective approaches. Yun and Shin [28] and Jung etal. [29] reduced the interference by adjusting the transmission power. Lopez Perez et al. [18] described the power control technique to restrict the transmit power at a femtocell. While the power control techniques at femtocell alleviate the co-channel interference, it may significantly vary the performance of FUE's, since reduction of the power of a femtocell also reduces the total throughput of femtocell users . From the point of view, resource management, Lopez - Perez etal. [7] suggested a framework to allocate different Resources with more different two users' requirements. Rahman and Yanikomeroglu presented dynamic interference avoidance Scheme to co-ordinate a group of neighboring cells [23]. However, this scheme was designed for macrocell base stations. In femtocell, the design of cognitive femtocell network studied. Attar etal. suggested that a cognitive base station can be exploit their knowledge of the radio scene for the interference management. Huang and Krishnamurthy [31] proposed the implementation of cognitive femtocell base stations for the resource allocation by using a game-theoretic frame work. With cognitive femtocell base stations, Lien recommended the insertion of sensing frames to scan the whole wireless resources periodically. When sensing the whole wireless resources that time femtocell cannot receive and transmit the data. The cognitive base station is required for the cognitive radio capabilities need to be incorporated into the femtocell base stations. Uygungelen etal also developed a graph-based dynamic frequency reuse (GB-DFR) as a resource allocation method based on the graph coloring. With the graph coloring algorithms, the assignment of PRBs to a femtocell is a restricted, since a vertex may only be assigned a single color. The DFP (dynamic frequency planning) was also proposed by Lópes Perez etal. [34] to decrease interference and reuse available sub channels in OFDMA networks. Lee et al. [11] proposed an adaptive fractional frequency reuse (FFR) algorithm where the FMS plans the coverage areas of femtocells according to the minimum acceptable signal strength of femtocells. The FMS allocates usable resources for the every femtocell in accordance with the number of cliques, which is formed by the union of neighboring femtocells. Sundaresan and Rangarajan proposed that each femtocell adopted a modulo-prime function and an interference topology to randomly access some frequency bands. The proposed DRA (distributed random access) scheme is specifically designed for co-channel and co-tiered deployment. However, different users might be allocated to the same wireless frequency bands with modulo-prime, where different users will acquire the interfering resources.

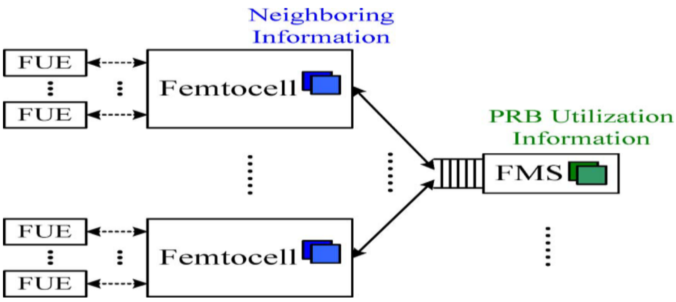


Fig. 1. Network model

The methods described in [11], [12], and [34] allocate fixed Sub channels to a femtocell, where a sub channel is composed of several PRB's within the same frequency band. Certain PRB's in the allocated sub channels may be used the femtocell, depending on the traffic conditions. If a PRB's in the sub channels are not fully utilized, the remaining PRB's can't be reused by another femtocells and are wasted. Through the proposed RAFF algorithm, all PRBs in a frame can be assigned flexibly instead of fixed sub channel assignment. The PRB's efficiency can be improved, and PRB's, as crucial and scarce wireless resources, can therefore be assigned to more femtocells.

PROBLEM STATEMENT AND ASSUMPTION:

We have assume a cellular system with femtocells deployed in the restricted indoor areas, such as home or enterprise environments. The coverage of randomly deployed in femtocells can be overlapped. Multiple femtocells are connected to FMS serving as a controller and the gateway toward the cellular system. The relationships between FMS's and other network components are depicted in Fig. 1, where FUE's, femtocells, and the FMS's constitute the entire femtocell networks. The neighboring femtocells operating on the same operator’s network may cause potentially high interference to each other. We visualize the scenario of the femtocell deployment as several groups in a densely deployed area, where the femtocells connected to one FMS are considered as in a group. Each group of femtocells is comprised of femtocells deployed in a geographically adjacent space. This grouping scheme renders that femtocells in more groups do not interfere with each other. In the proposed method, the FMS is applied to perform interference avoidance by using global information on femto interference. The framework of using global information enables FMS to perform better than femtocells do with only local information. The interference can be completely avoided through the adoption of the proposed method.

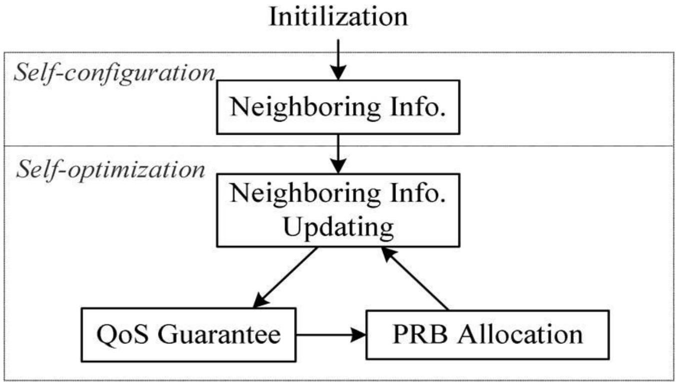


FIG. 2. SELF-ORGANIZATION STATES.

To reduce the interference among neighboring femtocells, a femtocell must be able to organize itself automatically. The deployment of femtocells with self-organization is crucial. In this paper, we consider that the resource allocation scheme automatically operates in a self-organizing network. The self organization mechanism includes self-configuration and self optimization, as depicted in Fig. 2. After initialization, the femtocell will configure itself. The femtocell assumed to the transmit a neighbor informing message with signal power twice as much as the regular information-bearing signal to overcome hidden terminal problem. The femtocell waits for a period of time for feedbacks from neighboring femtocells during self configuration of the system. The femtocell collects feedback messages and establishes the list of its neighbors. After the self configuration, the femtocell is in a operation mode and ready to provide services for FUE's. In the self-organization, the signals through FUE - to -femtocell and femtocell - to - FMS and FMS - to - Internet connections can be used to facilitate self-optimization. During self-optimization, neighboring information needs to be updated every fixed period of time to avoid stale neighboring list. We consider the scenario where each femtocell maintains its neighboring list.

Since the femto usage allows numerous femtocells to be randomly deployed in a certain area, the radio resources, i.e.PRB's, may not be sufficient to accommodate the huge demand from the applications. The conventional methods only consider the reuse of resources without QoS constraints. However, different connections require different amounts of PRB's to support the QoS specifications. In the proposed design, the QoS constraints, as measured by the required number of PRB's are taken into consideration in allocating PRBs, with the objective to improve PRB efficiency. In our design, each connection belongs to a single QCI in accordance with its application.

For example, the services of QCI 1–4 are applicable to the conventional voice, the conventional video, the buffered streaming, or real-time gaming. QCI 5–6 apply to IP multimedia signaling or live streaming, and QCI 7–9 apply to file sharing, email, P2P, or Web. Allocated resources must be sufficient to meet the requirements of the corresponding QCI's in both uplink and downlink transmissions. In other words, the appropriate resources must be allocated to the guarantee L2 packet delay budget, GBR limitation and the required data rate in each QCI. The delay budget and GBR requirements are explicitly defined in 3GPP.

PROBLEM MODELING:

The proposed optimization problem aims to pursue the maximization of PRB efficiency by allocating PRBs to avoid co-tiered and co-channel interference under the constraints of Frame utilization and QCI requirements. We call this problem the resource allocation optimization of femtocell-to-femtocell interference (OPT-FF) problem. To model the problem, a femtocell network is first defined as a graph G = (V,E), where V represents the set of vertices, and E represents the set of edges. Let v1 denote the FMS, V2 = {h1, h2, . . . , hM} the set of femtocells, and V3 = {u1, u2, . . . , uP } the set of FUEs, where the numbers of femtocells and FUEs are |V2| = M and |V3| = P, respectively.

As shown in Fig. 3, a femtocell is connected to one FMS, and an FUE is connected to one femtocell in a femtocell network. Let xi be the indicator to identify the link between the FMS v1 and the femtocell hi. Let yij be the indicator to identify the link between the femtocell hi and the FUE uj , which is expressed as

xi = 1, if (*v*1, *hi*) ∈ *E*1
0, otherwise
--- (1)

yij = 1, if (*hi, uj*) ∈ *E*1
0, otherwise.
--- (2)

Let the interference link *nij* between the femtocells *hi* and *hj*
be defined by

nij = 1, if (*hi, hj*) ∈ *E*2
0, otherwise.
--- (3)

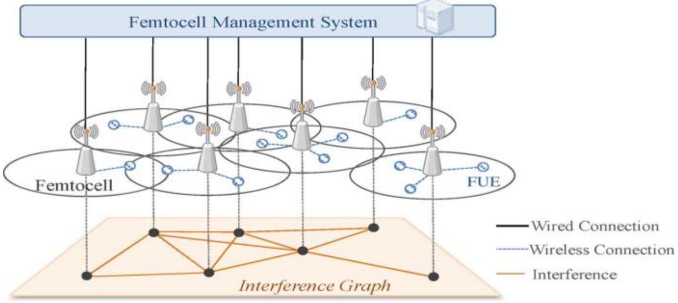
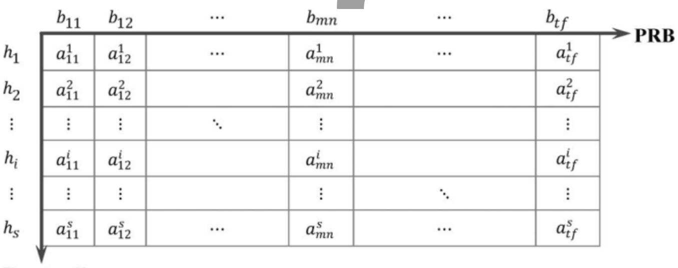


Fig. 3. Example of interference graph embedded in femtocell networks.



	b_{11}	b_{12}	⋯	b_{mn}	⋯	b_{tf}
h_1	a^1_{11}	a^1_{12}	⋯	a^1_{mn}	⋯	a^1_{tf}
h_2	a^2_{11}	a^2_{12}		a^2_{mn}		a^2_{tf}
⋮	⋮	⋮	⋱	⋮		⋮
h_i	a^i_{11}	a^i_{12}		a^i_{mn}		a^i_{tf}
⋮	⋮	⋮		⋮	⋱	⋮
h_s	a^s_{11}	a^s_{12}	⋯	a^s_{mn}	⋯	a^s_{tf}

Fig. 4. Resource frame maintained by a FMS.

Then, we denote a resource frame *B = {b*11*, b*12*, . . . , btf }* as the set of PRBs, where the number of time slots is *t*, and the number of frequencies is *f*. The number of PRBs per frame is denoted as *|B| = t.f* . In fact, the number of PRBs that can be reserved by a femtocell is restricted. We define *Bi* as the number of acceptable PRBs by the femtocell *hi*. Let*m* = 1 *. . . t* and *n* = 1 *. . . f*. To describe the assignment of the PRB *bmn*, an indicator parameter *ai mn* is defined as

ai
mn = *xi,* if *bmn* is allocated to *hi*
0, otherwise.
---------------------- (4)

The relation between the femtocell *hi* and the indicator *ai Mn* is shown in Fig. 4.

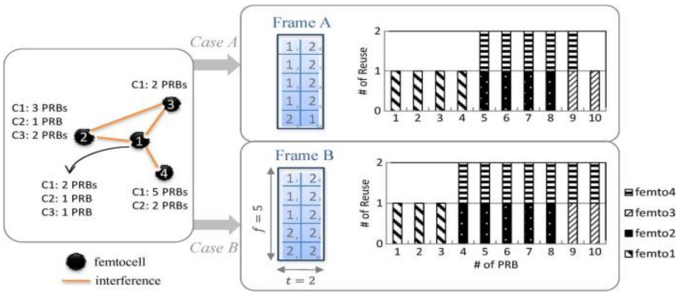


Fig. 5. Example of resource allocation.

COMPLEXITY ANALYSIS:

We analyze and compare the complexity of the proposed scheme with existing schemes. The original statement of low Complexity refers to the design of femtocells without considering the FMS. Most existing works rely on femtocells to handle the interference problem in resource allocations. Therefore, the femtocells require additional interference avoidance techniques to allocate PRBs, which incur complexities in the femtocells. In contrast, our proposed approach deals with the interference problems by the FMS since the FMS can be managed by the service provider and femtocells are customer-deployed low-cost devices with limited computational capability. Consequently, no additional allocation techniques are needed in femtocells. Due to the possible confusion, the description of low complexity in Section V is removed. Instead of the femtocell complexity, the orders of the overall complexities are compared as follows.

We analyze and compare the complexity of the proposed and existing schemes. The proposed scheme aims to find the maximum number of allocated PRBs for all femtocells. It requires sorting Q PRBs for M femtocells, where M represents the number of femtocells, and B is the number of PRBs. Hence, the total number of operations is approximated to ($4M + MQlogQ$), yielding a complexity of O ($MQlogQ$). The DFP algorithm [34] estimates the interference of resources among femtocells so that the interference of assigned resources can be mitigated.

The corresponding number of operations is ($QM2 - QM$)/2, yielding the complexity of O ($QM2$). The exact number of operations required by the adaptive FFR algorithm [11] is difficult to obtain due to the interference metrics and the heuristic nature of the algorithm. The number of operations is approximated to ($M3 - M2 + 2M - 2$). Therefore, the complexity of the adaptive FFR algorithm is O($M3$). The DRA scheme proposed by Sundaresan and Rangarajan [12] needs to iteratively hash resources of each femtocell .

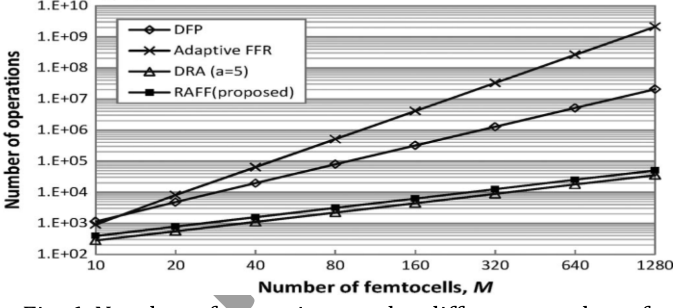


Fig. 6. Number of operations under different number of femtocells.

CONCLUSION:

To mitigate the co-channel and co-tiered interference and the high demand for PRB efficiency in femtocell networks, in this paper, we have explored the usage of FMS to assist the allocations of OFDMA resources. To exploit the spectrum resource and increase the PRB efficiency in the femtocells, we focus on the design of the efficient resource management scheme, where the resource usages are not predefined but dynamically allocated with QoS considerations. We propose the RAFF scheme to increase the spectrum efficiency and eliminate interference while maintaining the QoS requirements. Simulation results show that our mechanism provides 13% improvement in average throughput. Moreover, the rejection ratios of all QCIs are below 10%, and the success ratios of PRB allocations of all QCIs are higher than 90% in the HL scenario. Furthermore, the average PRB efficiency improves by 82% in the LL scenario and 13% in the HL scenario.

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