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Dynamic Spectrum Allocation for Network Utility and Throughput Maximization in Hybrid Access Cognitive Femtocell Network

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ABSTRACT: The cognitive femtocell is an important technology to solve the indoor coverage problem in future cellular networks also cognitive radio (CR) support dynamic spectrum access. In this paper, a new dynamic spectrum allocation method for network utility and throughput maximization in the hybrid access cognitive femtocell is proposed. In this method macro base station allocate channels to femto access point to serve macro users. In the proposed method Femto access point FAP allocates power and subchannels to indoor users to increase network utility, whereas the throughput of the served MUs is guaranteed.

KEYWORDS: Hybird access, Cognitive femtocell networks, dynamical spectrum allocation, dual decomposition.

I. INTRODUCTION

Femtocells were developed around 2005 in order to provide coverage inside building. Femtocells are small base stations that are generally deployed by consumer and connected to their own wired backhaul connection. Femtocell required low-power that provides coverage range of tens of meters, which is much smaller than that of macrocell. Femtocell is can be used to address the problem of the insufficiency of the spectrum and increasing demand of mobile users. A survey shows that around 50% voice traffic and 70% data traffic originate in indoor environments such as homes, offices, and airports [1]. However, due to multipath fading problem and wall penetration ,poor quality is received by indoor user due to that quality of service(Qos) is degraded. To solve indoor coverage problem femtocell provides increasing data rate and better indoor coverage due to reducing the distance between base stations and end users [2]. Also femtocells could improve the received signal strength for the indoor users due to the short transmission distance.

There are three types of access control technique in femtocell these are:

1) Closed access: In closed access FAP is accessed by only those FUs which are authorized by the FAP to transmit data, whereas the MUs are not allowed to access [3].
2) Open access: In open access both femto and macro end users can access the FAP [3].
3) Hybrid access: In hybrid access MUs are allow to access the FAP when the performance of the FUs are guaranteed. However, still there is problem releted to the allocation of subchannel and power because FAP has limed resources and how to share their limited resource with t.he MUs is still a problem.

Cognitive radio (CR) is a form of wireless technology which is the one of the most promising technologies in the future wireless communications [4]–[6].Cognitive radio networks is one that intelligently detect which communication channels are not in use and which are in use, accordingly channels are occupied by vacant channels and avoid channels which are vacant, because of this the spectrum efficiency of network increases [8] The femtocell networks integrate with cognitive radios recently have drawn much attention. The femtocell network works on the licensed cellular spectrum because of this femtocell network should seamlessly integrate with the cellular network. Thus, the spectrum insufficiency problem is becoming more serious due to the busy traffic and limited spectrum of cellular networks. In cognitive femtocell networks, the FAPs that are equipped with CR technology could avoid cross-tier and intratier interference to the macrocell and surrounding femtocells, as it dynamically sense spectrum usage by the macrocell and surrounding FAPs and optimize the overall usage of the spectrum. [3], [8].

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The proposed a dynamic spectrum allocation method is used to adopt hybrid access in cognitive femtocell network that serve MUs and FUS.

However, there are still several problems such as how to allocate subhannel and power to the MU's while maximize the femtocell network utility and guaranteeing the throughput of the served Mus.The paper is divided as follows. The related work in Section II. A system model is presented in Section III. Simulations are represented in section IV and conclusions in Section V.

II.RELATED WORK

The femtocell is one of the exciting technologies that could solve the poor indoor coverage problem with a little cost [9]. Different types of access control mechanism such as open, close, hybrid access was given in [10]. In [11], a Stackelberg game was employed to analyze the cooperation and competition between the wireless service provider and the femtocell holders. A utility-aware refunding framework motivate hybrid access in femtocell which enables WSP to compensate FHs for taking over macro traffic and encourages FHs to share femto resource with macro users[12]. In [13], Li et al. proposes resource allocation in open access OFDMA femtocell networks. To guarantee QoS of the neighboring MU in the Dead Zone and protect MUs from excessive cross-tier interference, they borrow CR technology in femtocell networks and propose a new resource allocation method from which the existing FUs and the newly added neighboring MU can benefit from. In [14], Propose an ACcess Permission (ACP) transaction framework, in which a single MSP purchases ACP from multiple FSPs in various locations throughout T timeslots, and FSPs who have overlapped coverage compete with each other for selling their ACP In [15], a distributed uplink power control algorithm was proposed, and it was applied to the hybrid spectrum access strategy in two-tier femtocell networks. The proposed algorithm can provide QoS support for all users while maximizing the network throughput. In cognitive femtocells, the FAPs that are equipped with CR technology could dynamically detect spectrum usage by the macrocell and surrounding FAPs, adapt their transmission to avoid cross-tier and intratier interference, and optimize the overall usage of the spectrum [3], [17]. In [18], In this paper, the problem of streaming multiple MGS videos in a femtocell CR network was investigated and Formulated a multistage stochastic programming problem considering various design factors across multiple layers and developed a distributed algorithm that can produce optimal solutions in the case of non-interfering FBS's, and a greedy algorithm for near-optimal solutions in the case of interfering FBS's with a proved lower bound. In [19], the static game framework was employed to solve the resource allocation problem In [21], several downlink spectrum sharing schemes were proposed according to the different availability of sensing information in the cognitive FAPs, and corresponding capacities were derived. In [22], the competition of the cognitive FAPs for spectrum resource was investigated however, as far as in reviewed papers there is no work that considers allocation of MUs while network utility of femtocell network is guaranteed. The propose dynamic spectrum allocation method for hybrid access cognitive femtocell network guaranteed performance of macro user while network utility of femtocell network is guaranteed.

II. SYSTEM MODEL

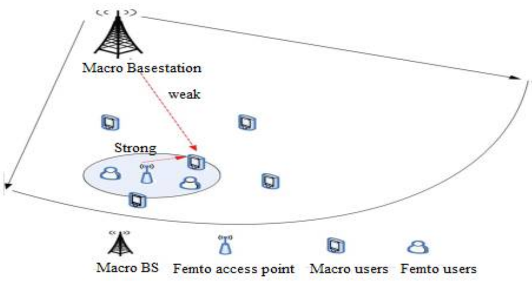

Fig1: System Scenario

Fig 1.Shows Two-tier network architecture. Here we considered only one macro base station and one femto access point (FAP).The FAP are connected to macro base station through wired backhaul, such as cable and fiber. There is

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difference between WiFi and Femto access points (FAPs).The FAPs work on the licensed cellular spectrum where as WiFi works on unlicensed spectrum. FAPs use the cellular standard to seamlessly integrate with the cellular network. The FAPs that are equipped with CR technology that dynamically detect the utilized channels by the macrocell and surrounding femtocells and occupy the remaining channel to avoid cross-tier and intratier interference to the macrocell and surrounding femtocells [19] , [20].

TABLE I
LIST OF THE MAIN VARIABLES

M	Number macro users in femtocell network
N	Number Femto users in femtocell network
B	Bandwidth of subchannels
D_m	The minimum rate of m-th Macro user
R	Transmission rang
S	Total number of sensed subchannels
Φ	Set of MUs in the Femtocell Network
Ω	Set of FUs in the Femtocell Network
Ψ	Set of users in Femtocell Network
J	Index of the a user in femtocell network
$\mu_{i,j}$	Subchannel allocation indicator of j-th user on subchannel i
Un(x)	Utility function of n-th FU
P_{FAP}	The maximum total transmission power of a FAP
$R_{i,j}$	Achievable rate of j-th user on subchannel i
m,n	Index of a MU and a FU
K_1	Uper-bound of the FUs' utility function
K_2	Reflection of the average demand level of the FU and fairness rules
$P_{i,j}$	Transmission power of j-th user on subchannel i

Here in this paper only one Femto network is considered in that, we use cognitive radio technology to detect channels which are not used by macro user and Femto user and allocate that channel to remaining macro users while allocating channel to the MUs network utility of Femto network and throughput of MUs is considered.
In this fig1.the OFDMA-based downlink transmission is considered. In this network there are a total of M MUs and N FUs. Let the set of the MUs in a cognitive femtocell be denoted $\Phi = \{1, 2, . . .M\}$and the set of the FUs denoted by $\Omega = \{1, 2, . . . , N\}$, respectively. The index of a MU denoted by $m \in \Phi$ and $n \in \Omega$ represents the index of an FU. The set of indoor end users is denoted $\Psi = \{1, 2, . . .,M + N\}$ that contains both MUs and FUs.each indoor end users is indexed by j, where $j \in \Psi$. The indoor end users communicate with the serving FAP by using OFDMA technique, in which consecutive subcarriers are bundled into a subchannel. The bandwidth of each subchannel is denoted B, and each subchannel is indexed by i. The FAP detect number of available channel by using spectrum sensing in each intervals. P_{FAP} represent transmission power of jth indoor user which is calculated at the time of assignment of channel. Here assignment of channel is denoted by binary function μi,j.Value of μi,j=1 denote channel is assigned and value of binary function 0 represent channel is not assigned. A list of the main variables used in this paper is given in Table I.

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III. PROPOSED ALGORITHM

The dynamic spectrum allocation method is implemented as follows:
Step 1: The mth MU goes into the area that the FAP covers.
Step 2: The macro BS calculates the number of subchannels q_m that the mth MU needs according to the mth MU's requirement
Step 3: If the FAP could satisfy the mth MU's requirement. That means if FAP fulfill the requirement of sunchannel and power of MUs it will allocate c_m subchannels, which are a part of q_m subchannels
Step 4: If the the network utility of the femtocell could increase by H percent when it serves the mth MU, the FAP decides to serve the mth MUs. Otherwise, the FAP will not serve the mth MU, and the macro BS needs to allocate more subchannels to the FAP to serve the mth MU. Note that procedure of the proposed method and spectrum sensing can be conducted by the femtocell simultaneously.
Therefore, the corresponding resource allocation strategy of the FAP can be formulated as follows [1]:

$$\max \sum_{n\in\Omega} U_n(\lambda_n) \qquad (1)$$

$$\text{s.t.} \quad \sum_{j\in\Psi} \mu_{i,j} \le 1 \qquad \forall i \in \gamma \qquad (2)$$

$$\sum_{i\in\gamma} \sum_{j\in\Psi} p_{i,j} \le p_{fap} \qquad (3)$$

$$\lambda_m \ge D_m \qquad (4)$$

Un(·) is the utility function. It is a concave and increasing function of data rates that reflects user satisfaction [23] and can be denoted as follows:

$$U_n(\lambda_n) = \begin{cases} k_1(1-e^{-k_2\lambda_n}), & \text{if } \lambda_n \ge 0 \\ -\infty, & \text{if } \lambda_n < 0 \end{cases} \qquad (5)$$

where λ_n is the achievable rate of the nth FU, λj is the achievable rate of the jth user on subchannel i. K_1 represents upper limit of the utility function, k_2 represents reflection of the average demand level of the FU and fairness rules and the value of k_2 is chosen to let utility equal to 0.9 k_1 .Un(·) is an increasing function. Utility increase fast when the achievable rate is smaller than the target rate t = 15 Mb/s.When the achievable rate exceeds the target rate utility increase slowly and allocate more resource to the end users that satisfy the target rate this will make little contribution to the utility function, and it can guarantee the fairness among the users. The constraint in (2) denotes that each subchannel can be allocated to only one user. Equation (3) indicates the power constraint of the FAP, and (4) means that the FAP should guarantee the requirement of the served MUs if it makes a deal with the macro BS [1].

IV. SIMULATION RESULTS

The Here, simulations are done to evaluate the performance of the proposed method using MATLAB. The simulation parameters are given in table II. Here we divided power to total indoor users and we allocate channels to each user. Fig .2 shows utility function. It is concave increasing function as given in equation 5.In the fig2. Utility increases fast when achievable rate is smaller than target rate and utility increases slows we achievable rate is greater than target rate here target rate is 15 Mbps.

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Fig 3.Shows network throughput with different number of sensed channels. Here throughput of each channel is calculated. Fig 3 shows throughput increases with different number of channels. Here we guaranteed throughput of each users. Fig 4 shows power consumption over different number of sensed channels. Here as channel is allocated to each user power consumption is calculated. As per equation 3 power of jth user should be less that total P_{FAP}.

Table II
Simulation Parameter

Macro users	4
Femto users	5
Power	0.05W
Channel	16
Range	15m
Floor	2
BW	1
Iteration	10000

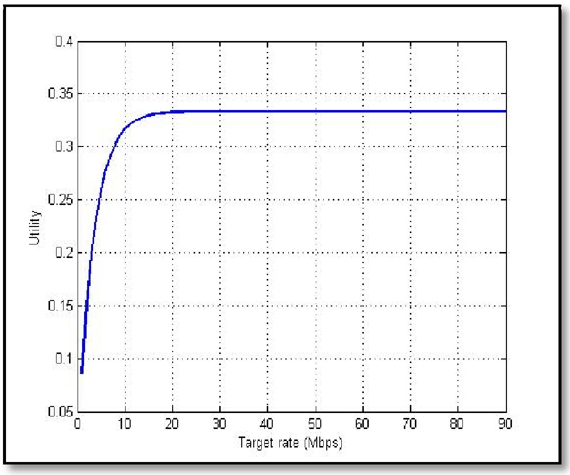

Fig.2. Utility Function

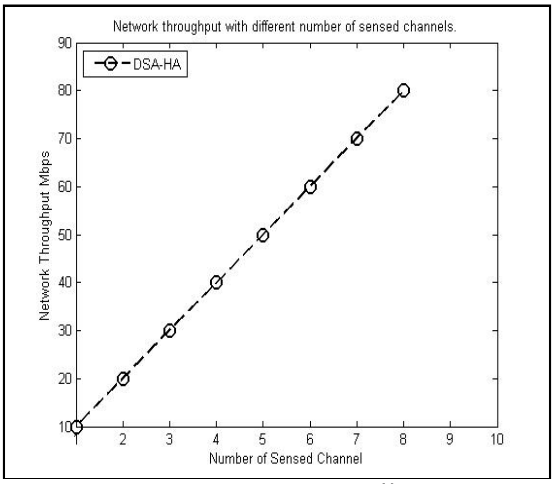

Fig. 3. Network throughput with different number of sensed channels.

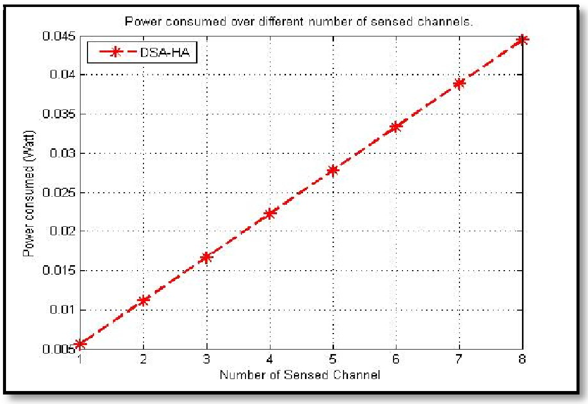

Fig 4.Power consumed over different number of sensed channels

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V. CONCLUSION AND FUTURE WORK

A dynamic spectrum allocation method to adopt hybrid access in the cognitive femtocell is proposed. Here, Macro base station allocates total 16 channels to Femto access point to serve Macro users. In this proposed method throughput of macro users is guaranteed where as network utility of femtocell increases.

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