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# Subchannel Assignment along with Power Control for Interference Mitigation for Femtocells by using Payoff based method

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**ABSTRACT:**Femtocell is one among the emerging recent concept. It is otherwise called as the home base stations. The femtocells are used by the people residing at home to achieve better indoor services. The femtocell base station is also called as the Femtocell Access Point (FAP). But when the femtocells are employed in huge numbers, then interference occurs. So, interference minimization is essential. The interference is of two types namely inter cell and intra cell interference. In order to avoid the interference the Distributed Subchannel Assignment is proposed in this paper and it is done by using the Payoff based method. This paper considers the downlink interference minimization problem in the OFDMA overlaid femtocells by means of Non Co-operative Rate Maximization (NRMG). In NRMG, each player chooses an action (strategy) exclusively which is efficient and gives benefit to them. For this NRMG game, existence of NE is important. The NE does not exist for the formulated problem, since the CSI (Channel State Information) is not taken into account. So, a state space is created which shows all the possible configurations. The simulation results presented shows that the proposed method achieves the Pareto-optimal solution as well as it improves the SINR to a greater extent. The simulation results also shows that the proposed scheme performs well when it is compared with the existing schemes.

**KEYWORDS:**Distributed Subchannel Assignment, OFDMA, Pareto-optimal solution, femtocells.

### I. INTRODUCTION

Techniques to improve the indoor coverage is very essential now a days. The various analysis shows that above 50% of the voice calls and above 70% of the data traffic comes from indoors [1]. So, in order to address the above said issues, femtocells are developed. Femtocells are low power base stations employed by the people in order to achieve good indoor coverage. The femtocell usually communicates with the operator's core network by a DSL, cable modem or through a RF backhaul channel. When femtocell is compared with the techniques such as microcells [2] and distributed antenna system [3], femtocell requires low cost. The salient features of the femtocell are good coverage, improved capacity and reliability, low cost etc. The main challenge faced by the femtocell is the interference because of the adhoc nature. The interferences are the intra cell or inter cell interference. Intra cell is the interference between the femtocells and macrocells. Inter cell is the interference among the femtocells or macrocells. So, effective interference minimization is required to improve the performance of the wireless communication networks [4]-[10].

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## II. RELATED WORK

The intra cell interference can be minimized by using two methods namely CDMA or OFDMA. Moreover when compared with the CDMA, OFDMA mitigates the interference to a greater extent [11]. So the intra cell interference is eradicated by using the technique OFDMA, in order to eradicate the inter cell interference, effective subchannel assignment scheme is required. The schemes for the subchannel assignment can be of two types namely centralized [12] or distributed. In the centralized scheme the number and the positions of femtocells are required. In this paper the distributed scheme is considered because the number of femtocells as well as the positions of the femtocell are unknown. The intra cell interference is not considered in this paper. The inter cell interference problem is formulated from the game theory point of view, since game theory is a very powerful tool to analyze design and control the multiagent systems [13]-[17]. So the Subchannel assignment problem is formulated as a Non Co-operative Rate Maximization Game (NRMG). In NRMG, each player chooses an action which is efficient and gives benefit to them. So the Payoff based method is developed based on the utility based learning technique [18]-[21] and an additional state space is inserted in the NRMG. The rest of the paper is organized as follows: In section III, System model is summed up. In Section IV, Overview of the proposed method is provided. In section V, Simulation results are analysed. The conclusion is provided in Section VI.

## III. SYSTEM MODEL

Consider a femtocell network where the femtocells are employed in random manner. Also consider that there are M femtocells. Since the femtocell is OFDMA overlaid femtocells, the femtocells share the spectrum which consists of S orthogonal subchannels with a bandwidth B. So, the intra cell interference is avoided in the network. But the downlink inter cell interference exists when the femtocells transmit using the same subchannels. To facilitate analysis assume that there is only one user communicating with the femtocell in each time interval. In this paper, the Payoff based method is proposed for the downlink communication. But optimizing the subchannels for the user is out of scope. Shadowing fading as well as the pathloss are considered in this paper to ease analysis. Let d is the distance between the user and the femtocell. The channel gain matrix is denoted by H. It is given by  $38.5 + 20 \log_{10}(d) + L_{\text{walls}}$  dB, where the wall loss  $L_{\text{walls}}$  is given by (15/10/7 dB for external/internal/high internal walls respectively). Also exchanging the channel state information in a multiagent system creates overhead. So the channel state information exchange is not considered in this paper. Power control is also considered in this paper. The power control is achieved by means of distributing the power uniformly among the subchannels.

So the power is given by

$$P_m^S = \frac{P}{S_n} \quad (1)$$

where,

$P_m^S$  is the power of FAP m on the subchannel S

P is the femtocell power

$S_n$  is the number of subchannel required

The Additive White Gaussian Noise (AWGN) is considered in this paper.

The Signal to Noise Ratio (SINR) is given by

$$\gamma_m^S = \frac{P_m^S H_m^S}{B N_0} \quad (2)$$

where,

B is the bandwidth of the subchannel

$N_0$  is the noise power spectral density

$P_m^S$  is the power of FAP m on the subchannel S

$H_m^S$  is the channel gain matrix of FAP m on the subchannel S

The Capacity C of the femtocell is given by

$$C_m = \sum_{m=1}^M B \log_2(1 + \gamma_m^S) \quad (3)$$

Next step is to formulate the problem as NRMG. So, the utility function is given by

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$$U_m = \sum_S B \log_2 \left( 1 + \frac{P_m^S H_m^S}{I_m^S + B N_0} \right) \quad (4)$$

where,

$I_m^S$  is the interference by other players caused to player m.

The Normalized Utility is given by

$$U_m^{\wedge} = (U_m(t)/F_m)^{\alpha} \in \{0,1\}, \forall t \quad (5)$$

where,

$F_m$  and  $\alpha$  are constants to normalize the utility function and  $\alpha$  belongs to  $[0,1]$ .

$$F_m = \max \{C_{m \max}\} \quad (6)$$

The probability for the player is given by

$$\rho_p = \varepsilon^{1 - (U_m(t)/F_m)^{\alpha}} \quad (7)$$

In NRMG, existence of NE is important. NE means each player is expected to take the best decision by taking into account the decisions of other players. For the formulated problem NE existence is not possible because the channel state exchange is not considered. So, there is a great challenge to design an efficient Distributed Subchannel Assignment scheme. The Payoff based method is proposed in the next section.

#### IV. OVERVIEW OF THE PROPOSED METHOD

The Payoff based method is based on the utility based technique. The terms player as well as the femtocell are used interchangeably in this paper.

##### A. Utility based Technique:

For NRMG, at the decision interval, the player will choose an action which is efficient and gives benefit to them. Payoff means the players have access only to their own action history and players have to decide an action based on that information. So such models can be used to study the multiagent systems because the channel state exchange is restricted because of the overhead in exchanging the messages. With small amount of information available, the convergence as well as the efficiency of the payoff based technique is unpredictable. So, a state space can be introduced which shows the all possible configuration of the game.

##### B. Payoff based method:

The Payoff based method is proposed based on the utility based technique. At each time t, the player first update the action required and the preference. After that the player try to access the history, then the player will choose an action based on the preference and the past history. In the above said method, it is observed that each player does not know other players and the channel state exchange is not required. Also the action chosen by opponents is also unknown.

##### C. Algorithm:

1. **Initialize:**  $t_n = 0$  (iteration count) and  $C_x$  is set to null vector.
2. **Set:**  $t_n = t_n + 1$
3. **for** m=1 to M users
4. **update** profile  $Q_n(t)$
5. **update** count  $C_x$
6. **end for**
7. **until** the number of iteration  $T_n$  is obtained
8. Each player chooses an action based on the final decision  $F_m^D = \max C_x$

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### D. Steps:

1. First and foremost the parameters are initialized i.e.,  $t_n = 0$  (iteration count) and the  $C_x$  is set to null vector.
2. Then the player will update the action required and the preference individually at every iteration  $t_n$ . i.e., it will update the profile  $Q_n(t) = (A_n(t), P_n(t))$  where  $A_n(t)$  is the action required by the player and  $P_n(t)$  is the preference required by the player.
3. Then the player will update the count  $C_x$  which is the strategy count.
4. When the entire loop is excited then the players have to make the final decision individually.
5. The final decision  $F_m^D = \max C_x$
6. The above said steps are stopped when the number of iteration  $T_n$  is obtained.

## V. SIMULATION RESULTS

Assume a circular region with radius  $r$ . Inside the circular region the  $M$  femtocells are generated in random locations. The below table 1 gives the simulation parameters.

Table 1 Simulation Parameters

PARAMETER	ASSUMED VALUE
Number of subchannel, S	9
Region radius, r	100 m
Bandwidth per subchannel, B	200 KHz
Number of subchannel required, $S_n$	7
The femtocell power, P	20dBm
The wall loss, $L_{walls}$	10 dB
AWGN noise power spectral density, $N_0$	-174 dBm/Hz

The above Table 1 gives the simulation parameters and the assumed values for Number of subchannel, Region radius, Bandwidth per subchannel, Number of subchannel required, femtocell power, wall loss, AWGN noise power spectral density etc.

### A. CONVERGENCE

The method is said to be obtained convergence if the proposed method achieves the Pareto-optimal solution. A method is said to be Pareto-optimal if the player can improve their performance without affecting the performance of the other players. The below figure 1 shows that the proposed method achieves Pareto optimal solution.

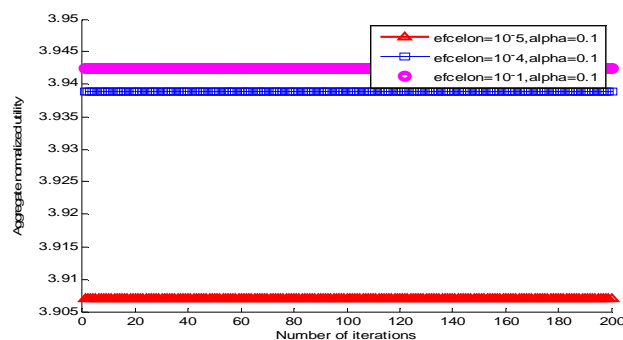


Fig.1 Pareto optimal solution

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From the figure 1 it is observed a straight line is achieved for various values of efcelon. A method is said to be Pareto-optimal if the player can improve their performance without affecting the performance of the other players. From the definition it is observed that straight line indicates that the presence of Pareto-optimal solution.

### B. AVERAGE SINR:

The proposed method is also analysed in terms of Average SINR for different values of femtocells. Moreover the proposed method is compared with the existing method named Distributed Subchannel Assignment [22]. The below figure 2 shows the SINR analysis and the proposed method is compared with the existing method.

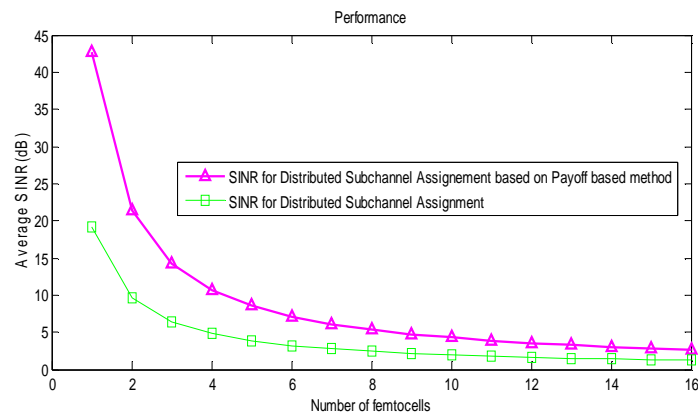


Fig.2 SINR analysis for sixteen femtocells

Figure 2 shows the SINR analysis for sixteen femtocells. From the figure it is observed that the SINR achieved is 44 dB and the SINR for the existing method [22] is 20 dB. So the interference is mitigated well by the proposed method.

The below Table 2 shows the Average SINR in dB when the number of femtocells is 4, 16 and 64 for the Existing method and the Proposed method.

Table 2 Average SINR in dB for various values of femtocells

No. of femtocells	Average SINR in dB(Existing)	Average SINR in dB(Proposed)
4	18 dB	42 dB
16	20 dB	44 dB
64	24 dB	48 dB

Table 2 shows the various Average SINR values for various values of femtocells. The various values for the Proposed method is compared with the Existing method. From the table it is observed that the interference mitigation capacity of the proposed method is better even for different values of femtocells.

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## VI. CONCLUSION

In this paper, the Payoff based method is proposed without channel state exchange. Also the proposed method achieves the Pareto-optimal solution. The simulation results shows that the proposed method mitigates and minimizes the interference to greater extent when compared with the existing method. Also the Proposed method works well for various values of femtocells.

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