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FEMTO CELL WITH DETERMINISTIC INTERLEAVER

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ABSTRACT

This manuscript intends to tell you about a downlink transmission scheme for femto cell networks grouping OFDM-IDMA. We assign macro users and femto users to a separate sub carrier groups for transmission to eliminate cross tier interferences. We use IDMA with deterministic interleaver, basically to mitigate the co-tier interferences within the same group of users. The system model and deterministic interleaver is explained clearly, the performance of the proposed scheme in terms of spectral efficiency and bit error rate (BER) is explained elaborately. Having analyzed the theoretical aspects and simulations demonstrates that with the combination of femto cell and grouping ,the proposed schemes levels better performance compared with usual OFDM-IDMA system and at the same time a lower complexity is exhibited than the later.

Keywords: *Deterministic Interleaver, femto cell, OFDM , IDMA, interference*

1. INTRODUCTION

The upcoming next generation (xG) wireless cellular network will provide very high data rate transmission. Due to high path loss, mobile users at the cell edge and indoor environment fail to maintain targeted quality of service (QoS), i.e., data rate and bit error rate. Thus the femtocell concept has been introduced by (Boudreau, 1999; Chandrasekhar, 2008). Femtocell are low powered, low cost, user deployed, self organizing base station that helps the users of macro cellular network to achieve high QoS at the indoor environment and cell edge. Interference is the main obstacle in heterogeneous, i.e., a mixture of macro and femto cells, multi-cell environment. A Macro cell Mobile Station (MMS) may receive interference from Femto Base Station (FBS) whereas a femtocell mobile station (FMS) may receive interference from macro and femtocell's. It can impair the spatial frequency reuse gain. Since FBSs are user deployed and installed without being planned, this increases the technical difficulties of interference management (Son, 2011).

The combination terms OFDM and IDMA has drawn intensive research interest in OFDM-IDMA system[1] , the OFDM is utilized to avoid the inter signal interference (ISI) caused by frequency selective fading ,and user separation is realized by equipping users with different interleavers. The combination of OFDM-IDMA gives an advantage of finding out interactive multi user detection (MUD). This is very effective in mitigating the multiple access interference (MAI) it is affirmed that the complexity of such MUD is linear with the number of users. This grouping of OFDM-IDMA system aims at reducing the detection complexity[2]. In such system, the available sub carriers are broken into several groups. Based on these group allocations, the total users are separated into subset and each one of them shares one group of sub carrier for their transmission. The users among different subset are separated by different sub carrier while the user within the same subset re distinguished by IDMA which bring out the number of users in each group is lesser than the traditional OFDM-IDMA system hence leading to minimized complexity. However the complexity of MUD

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not only related to the number of interaction of MUD users but also relates to the number iteration of MUD. To achieve a sustained promising performance the MUD should work under sufficient number of iteration. The complexity would be still very high if the number of iteration is large. Considering a downlink scenario where the receiver is mobile used equipment. Such complexity may be a great load and hence prohibit IDMA from implementation in such an occasion.

In this paper we focus on interference mitigation of OFDM IDMA based femtocells underlay in macro cellular networks. In OFDM-IDMA systems, OFDM is employed to avoid the inter symbol interference (ISI) caused by frequency selective fading, while user separation is realized by equipping users with different interleavers. One advantage of OFDM-IDMA is its capability for iterative multi-user detection (MUD), which is proved to be effective in mitigating the multiple access interference (MAI) [3]. It is also reported that the complexity of such MUD is linear with the number of users [4].

2. FEMTOCELL NETWORK

The Femtocell network is a novelty emerging architecture which can enhance the performance of the macro cellular systems [5], [6]. One femtocell can be treated as a small cellular network consisted of one femto access point (FAP) with low transmit power and several femtousers (FUs) under its coverage. It provides high-quality transmission links thanks to the close transmission range between the FAP and FUs. In addition, the computing capability of FAP allows certain pre-processing operation such as decoding, before it forwards the information from the macro base station (MBS) to the FUs, which further improves the communication quality. Due to its superior benefits, the concept of femtocell is widely adopted in various standards including Long-term evolution (LTE),where the OFDMA based femtocell is referred to as home evolved node base station (HeNB) [7]. However, despite of its envisioned benefits, additional interference is also caused by introducing femtocell into the existing macrocell. The interference can be classified into two categories, namely cross-tier interference and co-tier interference. The former is caused by simultaneous transmission between the femtocell and macrocell while the latter is due to the simultaneous transmission within/between femtocells [8]. Therefore, it is a challenge to design efficient transmission scheme for femtocell network in present of interference.

Many interference mitigation techniques have been reported in the literature. The interference generated by the FBS cannot be handled by the macrocell network operator by means of centralized network planning (Boudreau,1999; Calin, 2010; Galindo, 2010). Thus the interference management in femtocells underlay in macro cellular networks is distributed. Giuliano et al. has proposed fractional frequency reuse (FFR) for wimax and 3GPP LTE in rural environment. In FFR the whole frequency bands were partitioned into sets of sub-channels and orthogonal sub-channels sets are assigned to adjacent users to mitigate interference. Boudreau et al. has discussed Static FFR and Adaptive FFR techniques. Two FFR with frequency hopping have been discussed in (Boudreau, 1999; Juang, 2010). The authors showed that in compared to the static FFR, the dynamic FFR reduced the downlink interference significantly. Performance of macro and co-channel femto has been investigated in (Kim, 2010). Clausseu has also proposed that the transmit power control of FBS based on handoff statistics has reduced the interference considerably.

The femto cell network is an emergency architecture which can enhance the performance of the macro cellular system. One femto cell can be treated as a small cellular network consisted of one femto access point (FAP) under its coverage. Due to close transmission range between FAP and FUS a high quality transmission linear to provide. In addition there is a tremendous improvement of communication quality because of certain pre processing operations, by the compiling capability of FAP ,such as decoding , before it forward information from the macro base station (MBS) of the FUS. Because of the highlighted benefits, the concept as femto cell is widely adopted in various standards including long term evolution (LTE), where OFDMA based femto cell is referred to as home evolved node base station (HENM). However an additional interface is also cause by introducing femtocell into the existing macro cell, despite of its

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envisioned benefits. The interference is identify in to two categories, one is cross tier and other one is co tier. The cross tier interference is caused by simultaneous transmission between the femtocell and macro cell while the co tier interferences causes between or within femtocells. Therefore its challenge to design efficient transmission scheme for femtocell network in the presence of interference.

In this presentation its proposed to adopt G-OFDM-IDMA for the downlink transmission of femtocell network, aiming at combining the advantages of both. i such a practice cross tier interference could be totally avoided by assigning macro user and femtocell users in to different subcarrier groups. within the same group IDMA with deterministic interleaver namely modified circular shift interleaver could be employed to distinguish co-tier user. the numbers per group could be reduced in order to get lo complexity. Alternatively due to competing capability of FAP (femto cell Access Point), the transmitter signal from MBS (Macro Base Station) to FU (Femto User) can be decoded first by FAP with sufficient iterations, and then forwarded to FU's with relatively high power reception. The guaranteed performance the user is ensured with the small or insufficient number of iterations. The practical OFDM-IDMA downlink is possible with a reduced decoding complexity as well as good performance. In this paper spectral efficiency followed by bit error rate (BER) is archived .An simulation result that with the help of femto cell grouping the proposed transmission scheme provides better performance compared with that of the macro cell scenario employing traditional OFDM-IDMA and further the decoding complexity at the user end is greatly reduced.

3. SYSTEM MODEL

We have considered a two tier femtocell network with one macro base station and one femtocell access point as shown in figure 1.The total users are denoted as K and the macro users are denoted as Km they receive signal directly from the MBS and femtocell users are denoted by K_f they receive signal from FAP. In order to make our analysis is easy we assume that K_m=K_f. The available N subcarriers are evenly divided among the femtocell user and macro user group ,such that each set of users can have one group for their transmission.[12,13]. As shown in figure2 the activities of each group are explained as follows the data of different users are encoded by a convolutional encoder and then modified circular shift interleaver is used to differentiate them resulting in an independent permuted code sequence. These data's are modulated using QPSK symbols respectively, and combined together to be transmitted on the corresponding group. The received signal at the k-th MU on subcarrier n can be explained as

$$Y_k(n)=H_k(n)X_k(n)+H_k(n)\sum_{\substack{k'\neq k\\ k'\in km}} X_{k'}(n)+w(n)$$

(1)

where k_m belongs to MU's , $X_k(n)$ is the k^{th} user data on nth subcarrier.$H_k(n)$ denotes the channel response on the nth subcarrier between MBS and the user k, w(n) denotes the AWGN on the nth sub carrier with zero mean and σ^2 variance.

Similarly the received signal at the FAP

$$Y_b(n)=H_b(n)\sum_{k\in k_f} X_k(n)+w(n)$$

(2)

where $H_b(n)$ denotes the channel response on subcarrier n from the MMS to the FAP.

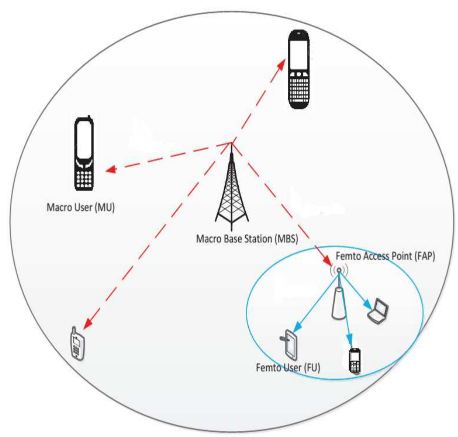

Figure 1 Representation of FEM to cell network

The received signals from the transmitter starts to recover the signals using MUD (Multi User Detection)[14].The MUD consists of Gaussian approximation detector(GAD) and K_m detectors which works in an iterative manner to retrieve the data's. The interference along with noise component is suppressed using central limit theorem. The Log Likelihood ratio are then interleaved and send to the decoder. The decoder generates its own LLR and feedback to GAD to update the information. This procedure is

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operated for several iterations and then finally hard decision is arrived.

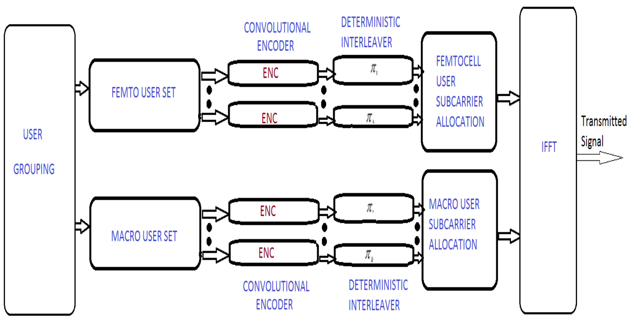

Figure 2 Transmitter Model

4. DETERMINISTIC INTERLEAVER

The proposed deterministic interleaver is given the name Modified Circular shift Interleaver since the mathematical model is incorporated from the existing circular shift interleaver. The design methodology and mathematical model is discussed in detail in the following paragraph.

i. Mathematical Model

The mathematical model of circular shifting interleaver which uses a random interleaver is given in equation..The permutation p of the circular shifting interleaver is defined by

$$P(i) = (a\,i + s) \bmod L \qquad (3)$$

Satisfying a < L, a is relatively prime to L, and s < L

Where i is the index, a is the step size and s is the offset.

The mathematical model of proposed deterministic interleaver[15] as shown in figure 3 is modified as

$$\pi(i) = (p * i) \bmod N \qquad (4)$$

Where p is a prime number and .N is the overall bits transmitted. Here 'i' indicates the bit position.

ii. Design Procedure

For convenience the mathematical can be expressed in terms of digital signal representation x(n).

x ('n' new position)=x('n' old interleaved pos

$$x(m) = \pi\, x(n) \qquad (5)$$

$$\text{And} \quad x(n) = \pi^{-1} x(m) \qquad (6)$$

$$x(n) = (p * n) \bmod N \qquad (7)$$

where p is a prime number ,N is the maximum length of x(n) and n=0 to N-1.

The expression in equation 5 indicates the interleaver and equation 6 indicates the deinterleaver. They are obtained by using the inverse modulus property. The only restriction is that p and N should not have common factors. If this fails no interleaving pattern will be obtained.

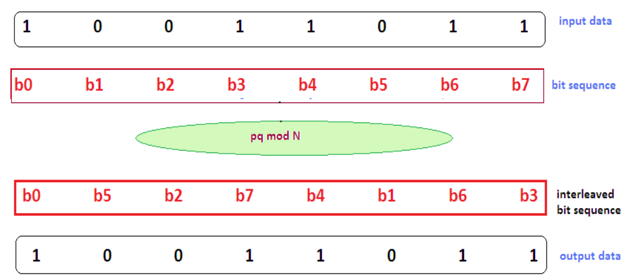

Figure3 Proposed Deterministic Interleaver

5. PERFORMANCE ANALYSIS

In this section the performance of the grouped OFDM IDMA is analysed in terms of spectral efficiency and BER. Then the complexity of the proposed system is compared with the traditional OFDM-IDMA.

i. Spectral Efficiency

With the help of SNR evolution method we obtain the spectral efficiency of the proposed scheme [16] as shown in figure 4.We the equal power allocation between the users, the transmit power is calculated as follows,

P_t = Power of the information bit /Macro user spreading code length. (8)

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Considering the down link ,the achievable spectral efficiency between the MBS and the k-th MU is obtained as

$$C_k = \log 2(1+ (SINR)_k^{(\text{no of iteration})}) \quad (9)$$

According to the assumption FUs and MUs belong to the same equipment their computing capability are treated equally with same amount of iterations q^{th} macro and femtocell user. Since FAP has a closer transmission range it receives higher received signal power at the FUs .So C_f is greater than C_m where C_f is spectral efficiency of femtocell and C_m is the spectral efficiency of macrocell. Thus entire spectral efficiency is the sum of that two user set.

$$C_{sys} = C_f + C_m = \min\{C_b , C_f\} + C_m \quad (10)$$

where C_b is the transmission between the MBS to FAP and the C_f is the transmission between the FAP and FUs.

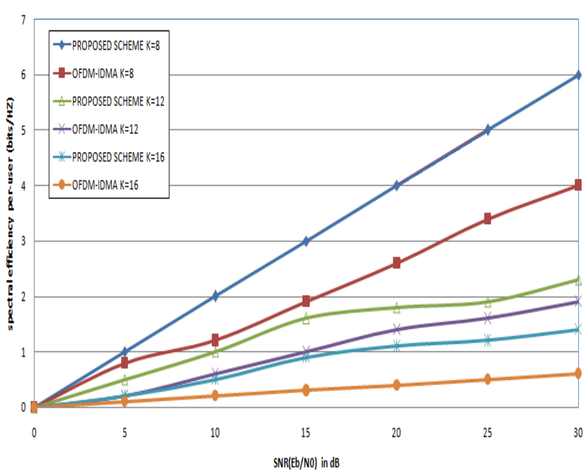

Figure 4 depicts the spectral efficiency of single femtocell and traditional OFDM-IDMA.

ii. BER Performance

In this we study the performance of the proposed system with different number of user's .The performance of traditional OFDM-IDMA is also illustrated with different users as shown in figure 5. The proposed scheme always outperforms the traditional scheme and the performance gap increases as the number of users decreases. It is proved that by introducing the femtocell and grouping technique the system performance is enhanced greatly.

Table 1. System description

	Value	Description
N_C	512	No. of subcarriers
S	8	Spreading Length
P_b	P + 12dB	Signal power of FUs
K	8,12,16	Total User Number
	4,6,8	Femtocell User's and Macro cell user's
Q_u	4	Number of iterations at UE
Q_b	12	Number of iterations at FAP
M	QPSK	Modulation used
Π	pqmodK	Modified circular shift Interleaver

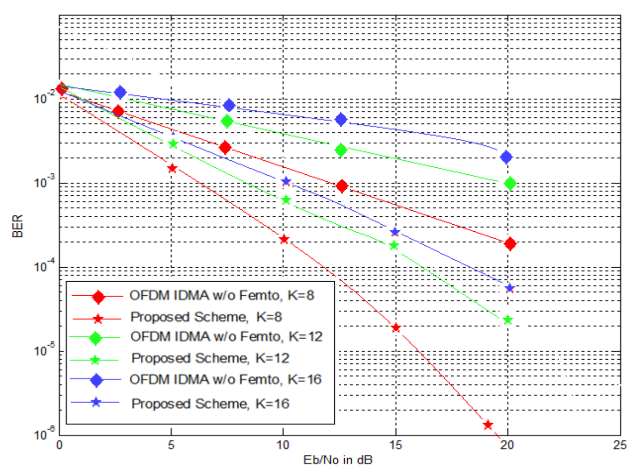

Figure 5 BER comparison with single Femtocell and traditional (without Femtocell) OFDM-IDMA

To enhance the performance enhancement in introducing grouping and femtocell independently we illustrate the BER performance of MU set and FU set of the proposed scheme as shown in figure 6.From the figure we can infer that always FU set performs better than MU set. The Femtocell User's are benefited from grouping as well as they are placed close to the FAP .The gap between the macrocell BER and femtocell BER is narrowed along with the reducing number of user's. When the number of user's are small a fixed iteration can be used among the femtocell and macrocell user thus their BER performance are similar.

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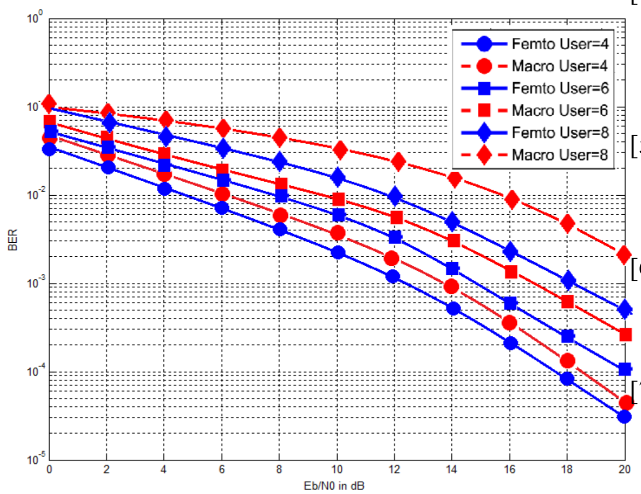

Figure 6 BER performance of MU set and FU set of the proposed scheme

6. CONCLUSION

In this paper a novel deterministic interleaver is implemented with grouping methodology to improve the performance during a downlink transmission. The cross tier and co tier interferences are suppressed by using different sub groups and different interleavers respectively. The BER and spectral efficiency of the proposed scheme is evaluated and analyzed which shows a drastic good performance over the traditional OFDM-IDMA. By introducing Femtocell, grouping and deterministic interleaver remarkable performance is achieved. In future more deterministic interleavers can be introduced to obtain good performance.

REFERENCES:

[1] Ping, L., Guo, Q. & Tong, J, "The OFDM-IDMA approach to wireless communication systems", IEEE Wireless Communications,2007.

[2] Xiaotian Zhou, Haixia Zhang and Dongfeng Yuan, "A Novel G-OFDM-IDMA Based Downlink Transmission Scheme for Femtocell Networks", JOURNAL OF COMPUTERS, VOL. 8, NO. 3, MARCH 2013

[3] P. Li, L. Liu, K. Wu, and W. K. Leung, "Interleave division multiple access," IEEE Trans. on Wireless Communications, vol. 5, no. 4, pp. 938–947, April 2006.

[4] L. Liu, J. Tong, and P. Li, "Analysis and optimization of CDMA systems with chip-level interleavers," IEEE Journal on Selected Areas in Communications, vol. 24, no. 1, p. 141¨C150, January 2006

[5] V. Chandrasekhar, J. G. Andrews, and A. Gatherer, "Femtocell networks: A survey," IEEE Communications Magazine, vol. 46, no. 9, pp. 59–67, September 2008.

[6] H. Claussen, L. Ho, and L. G. Samuel, "An overview of the femtocell concept," Bell Labs Techn. J., vol. 13, no. 1, pp. 59– 67, May 2008.

[7]N.Saquib, E. Hossain, L. B. Le, and D. I. Kim, "Interference management in OFDMA femtocell networks: Issues and approaches," IEEE Wireless Communications, vol. 19, no. 3, pp. 86–95, June2012.

[8] D. Lopez-Perez, A. Valcarce, G. de la Roche, and J. Zhang,"OFDMA femtocells: A roadmap on interference avoidance,"IEEE Communications Magazine, vol. 47, no. 9, pp. 41 –48,September 2009.

[9]Boudreau, G., Panicker, J., Guo, N., Chang, R., Wang, N., & Vrzic, S. (1999). Interference coordination and cancellation for 4G networks. IEEE Communication Magazine, 47(4), 74-81.

[10]Juang, R. T., Ting, P., Lin, H. P., & Lin, D. B. (2010). Interference Management of Femtocell in Macro-Cellular Networks. http://dx.doi.org/10.1109/WTS.2010.5479646.

[11]Kim, Y. Lee, S., & Hong, D. (2010). Performance Analysis of Two-tier Femtocell Networks With Outage Constraints. IEEE Trans. on Wireless Comm., 9, 2695-2700.

[12] X. Zhou, L. Yang, and D. Yuan, "A bipartite matching based user grouping method for grouped OFDM-IDMA systems," in *Proc. of Military Communication Conference*, Orlando, FL, USA, October 29–November 1, 2012, pp. 576–581.

[13] H. Myung and D. Goodman, *Single Carrier FDMA: A New AirInterface for Long Term Evolution*. John Wiley & Sons, July 2008.

[14] P. Li, L. Liu, K. Wu, and W. K. Leung, "Interleave division multiple access," *IEEE Trans. on Wireless Communications*, vol. 5,no. 4, pp. 938–947, April 2006.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[15] Juliet, A. Mary, and S. Jayashri. "Design analysis of deterministic interleaver for OFDM-IDMA system." *Signal Processing Image Processing & Pattern Recognition (ICSIPR), 2013 International Conference on*. IEEE, 2013.

[16] J. Dang, W. Zhang, L. Yang, and Z. Zhang, “OFDM-IDMA with user grouping,” *IEEE Trans. on Communications*, in press 2013.