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Performance Analysis of Energy Efficient Power allocation for Secure OFDMA based Cognitive Radio Networks

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ABSTRACT: In this paper, we are analyzing the performance of energy efficient power allocation for secure orthogonal frequency division multiple access (OFDMA) based cognitive radio networks (CRN's). The power allocation schemes are optimized for maximization of the energy efficiency [4] in secure data transmission. The nonconvex optimization problem takes into account to maximize the energy efficiency measured using the total throughput per Joule subject to the total transmit power and interference constraints. The nonconvex optimization problem is transformed into an equivalent convex optimization problem using by parametric programming method. The simulation results show that the proposed optimization algorithm can achieve higher energy efficiency, less bit error rate (BER) than that obtained by solving the original problem directly due to non convexity problem and also achieve a good tradeoff between rate channel capacity and interference threshold in cognitive radio networks.

Key Words: OFDMA, BER, CRN, RAN

I. INTRODUCTION

Orthogonal Frequency Division Multiple Access (OFDMA) is regarded as one of the prime multiple schemes for wireless networks. Spectral efficiency plays an important role in achieving high data rate in wireless communication. Efficient usage of energy is important for wire communication as well as wireless communications.Radio resource management schemes are mainly concentrating on maximizing the spectral efficiency of OFDMA systems rather than maximizing total throughput of the system. In wireless Communication, it is important to minimize the total transmit power consumption [1] in RAN's.It is important to find out the tradeoff between minimum power consumption and energy efficiency. Radio resource allocation in OFDMA based systems mainly depends on total transmit power and data rate. So we are formulating the energy efficient resource allocation schemes with reduced complexity.OFDMA plays an important role in future cognitive radio networks. It also allows changing the spectral environments dynamically by allocating unused spectrum to the secondary users. Spectrum utilization can also be improved by using OFDMA to overcome the frequency selective fading. Energy efficient power allocation [2][3] algorithms are necessary to optimize bit error rate, transmission channel capacity, and transmit power in OFDMA based cognitive radio networks.

Our ultimate aim is to increase the channel capacity and energy efficiency of CR users by limiting the interference [6] introduced to the primary user system. From the simulation results we can conclude that the proposed optimal algorithms offer better energy efficiency and channel capacity which is very close to the uniform optimal algorithms.

II. SYSTEM MODEL

Energy efficiency and Spectral efficiency are plays an important role in wireless communication systems. The increase in demand for frequency bands with high data rate requirements, we are in a need to efficiently utilize the available spectrum with better energy efficiency. So cognitive radio (CR) networks are plays vital role in utilizing the available unused spectrum efficiently with better energy efficiency.

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A. System Model of OFDMA based CR systems

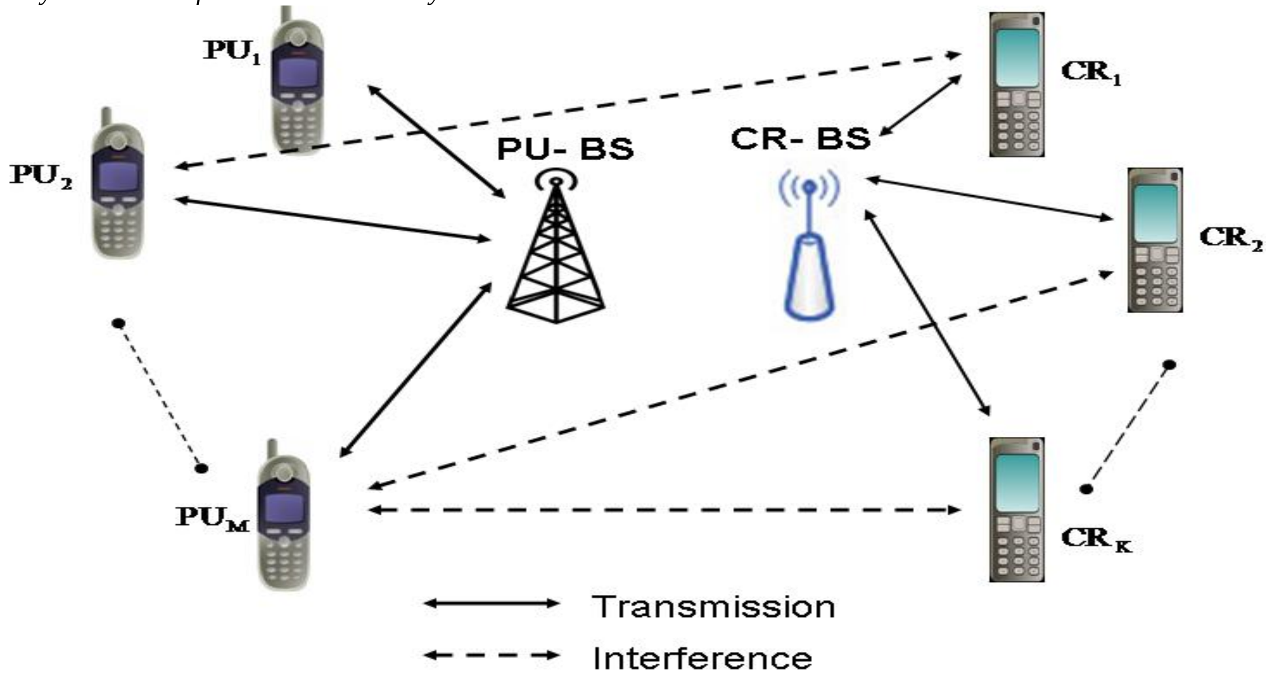

Figure 1. Block Diagram of OFDMA based CR systems

In this paper, Figure 1 shows the block diagram of OFDMA based CR Systems for uplink [5] as well as downlink. It shows the signal transmission between PU and Primary User (PU)-Base Station (BS), SU and Cognitive Radio (CR)-Base Station (BS).It also sows the interference between PU's and SU's. In this each Primary radio networks (PRN) cell has one PU-BS and multiple Primary Users. Each Cognitive radio network (CRN) cell has one CR-BS and multiple SU's. The primary cell system coexists with the CR cell system in the same geographical location.CRN cell system control the interference to the PU's as well as the intercell interference and signal transmission to SU's.The secondary users (SU's) can be able to access the available CR Bands without causing harmful interference to the primary users.

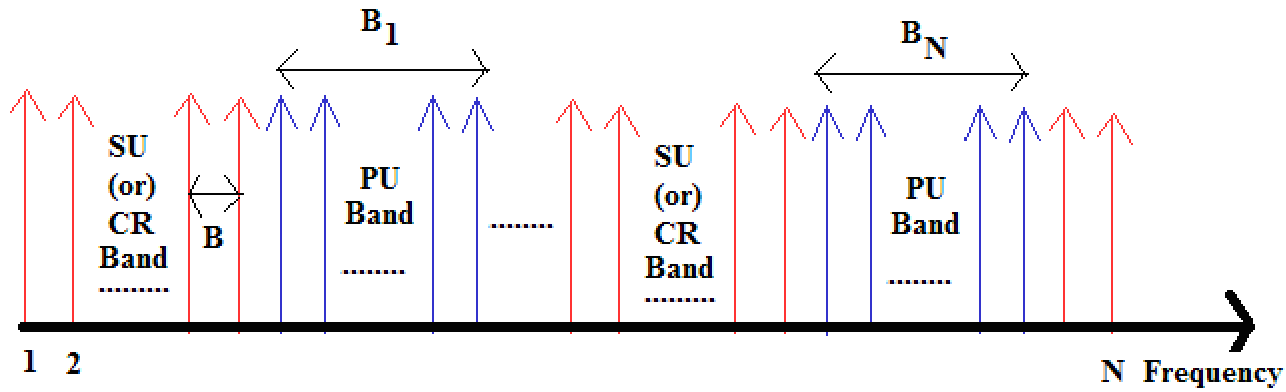

Figure 2. Spectrum Frequency band for PU's & SU's

Figure 2 shows the spectrum frequency band for PU's and SU's. The CR frequency spectrum band is divided into N subcarriers which are applied to OFDMA system having a bandwidth of 'B'.The side by side distribution of spectrum frequency band for PU bands and the CR bands will be assumed by showing in figure 2. The frequency bands $B_1, B_2, \cdots, B_N$ has been occupied by the PU's are called as PU bands while the other bands are called as SU bands (CR bands). It is assumed that the CR system can use the inactive PU bands provided that the total interference introduced to the M^{th} PU band [10] does not exceed remaining all the bands. We also achieve a tolerable interference power and interference temperature limit.

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We can use Cognitive Radio networks, to establish communication among unauthorized users without affecting the use of spectrum. Energy efficient power allocation [8] is necessary for OFDMA based Cognitive Radio networks to achieve the maximum energy efficiency and less interference.

III. DESIGN METHODOLOGIES

Effective energy efficient power allocation algorithms [7] are needed in order to maximize the channel capacity of CR networks by considering the two factors channel state Information and maximum tolerable interference limitation. The interferences introduced into the primary user's band must not exceed from a tolerable level.

We can write the optimization problem by mathematically

$$\sum_{k=1}^{K}\sum_{n=1}^{N} B\log_2\left(1+\frac{p_{k,n}h_{k,n}^2}{\left(N_0\frac{B}{N}\right)+\sum_{k=1}^{K}\sum_{n=1}^{N}\sum_{m=1}^{M} I_{tol\,k,n}^{m}}\right) \quad \text{--- (1)}$$

Subject to

$$\sum_{k=1}^{K}\sum_{n=1}^{N} p_{k,n} \le P_{Max} \quad \text{--- (1a)}$$

$$p_{k,n} \ge 0 \quad \text{for all k, n} \quad \text{--- (1b)}$$

Where

N	- Total number of subcarriers
M	- Total number of Primary Users
K	- Total number of CR users
N_0	- Power spectral density of additive white Gaussian noise
B	- Bandwidth of particular frequency band
$p_{k,n}$	- Transmit Power allocated for k^{th} CR user of n^{th} subcarrier
$h_{k,n}$	- Channel gain for k^{th} CR user of n^{th} subcarrier
$I_{tol\,k,n}^{m}$	- Interference introduced into m^{th} primary user of k^{th} CR user of n^{th} subcarrier
P_{Max}	- Maximum power

IV. PROPOSED ALGORITHMS

The proposed algorithm for Power allocation is compared with existing algorithms how close they come to the optimum allocation.

A. Proposed Optimal Power Allocation

After assigning subchannels to the users by using subcarrier allocation algorithm, we can allocate the power according to channel state information from all the users to achieve maximum transmission capacity to CR users by allowing the interference introduced into the primary users below the threshold value. Transmit power may vary according to data rate for the number of users.

The optimal power allocated to k^{th} CR user of n^{th} subcarrier is given by the following equation.

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$$p_{k,n} = \left[\frac{1}{\gamma} - \frac{\sum_{k=1}^{K} \sum_{n=1}^{N} \sum_{m=1}^{M} I_{tol\,k,n}^{m}}{N_0 \frac{B}{N} \sum_{k=1}^{K} \sum_{n=1}^{N} h_{k,n}^{2}} \right] \quad \text{--- (5)}$$

Where

γ - The Lagrange multipliers

V. RESULTS AND DISCUSSIONS

The performance of proposed algorithm can be shown in the simulation results by using MATLAB 7.9.The simulation parameters are Total number of subcarriers N=256, Total number of Primary Users M=20, Total number of CR users K=15, I_{tol}=1x10^{-6},P_{max}=1x10^{-4}, BER=1x$10^{-1.5}$, Bandwidth B= 100 MHz .

A. Simulation Results

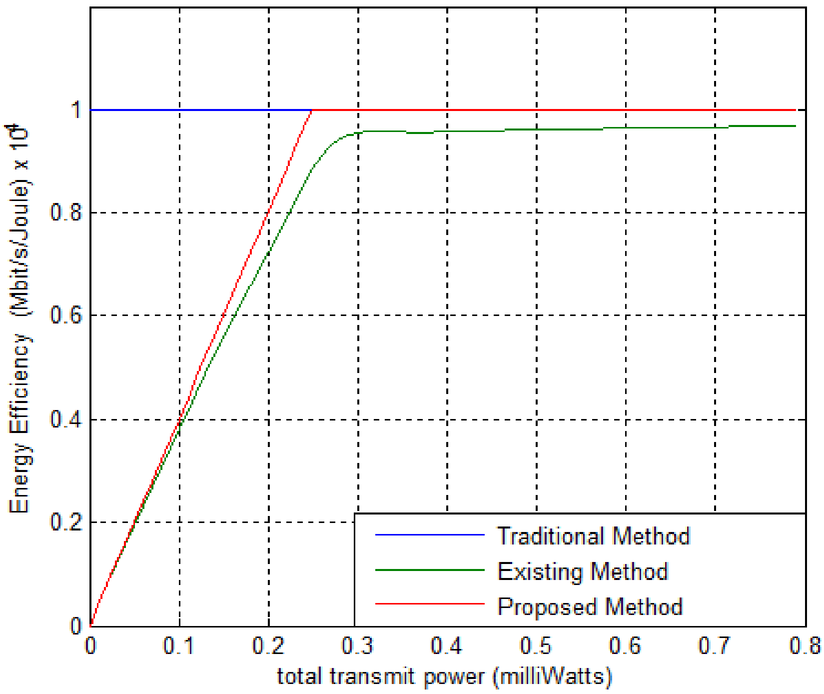

Figure 3. Total transmit power Vs Energy Efficiency

Figure 2 shows the simulation result of total transmit power versus Energy efficiency.

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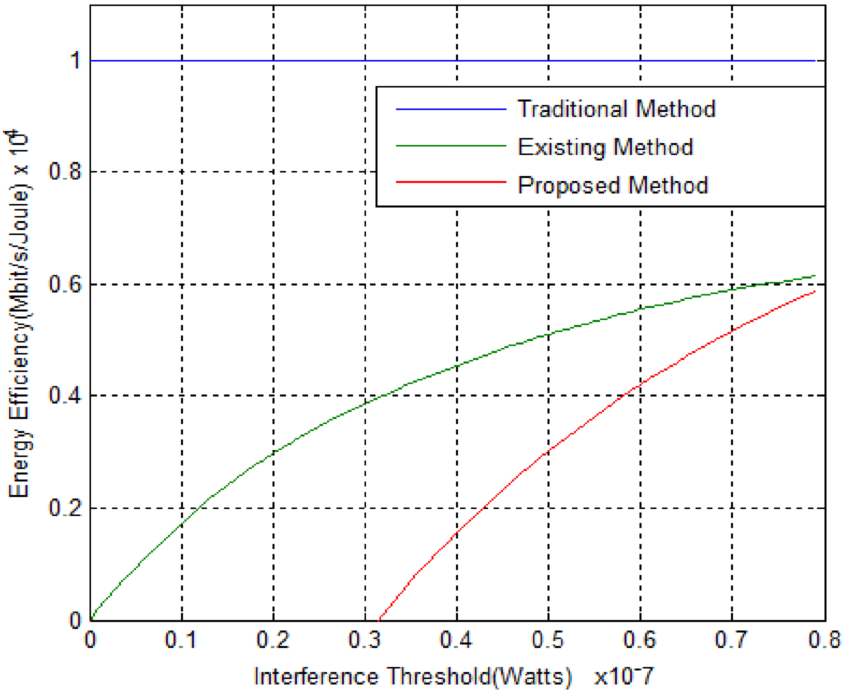

Figure 4. Interference threshold Vs Energy Efficiency

Figure 3 shows the simulation result of interference threshold versus energy efficiency.

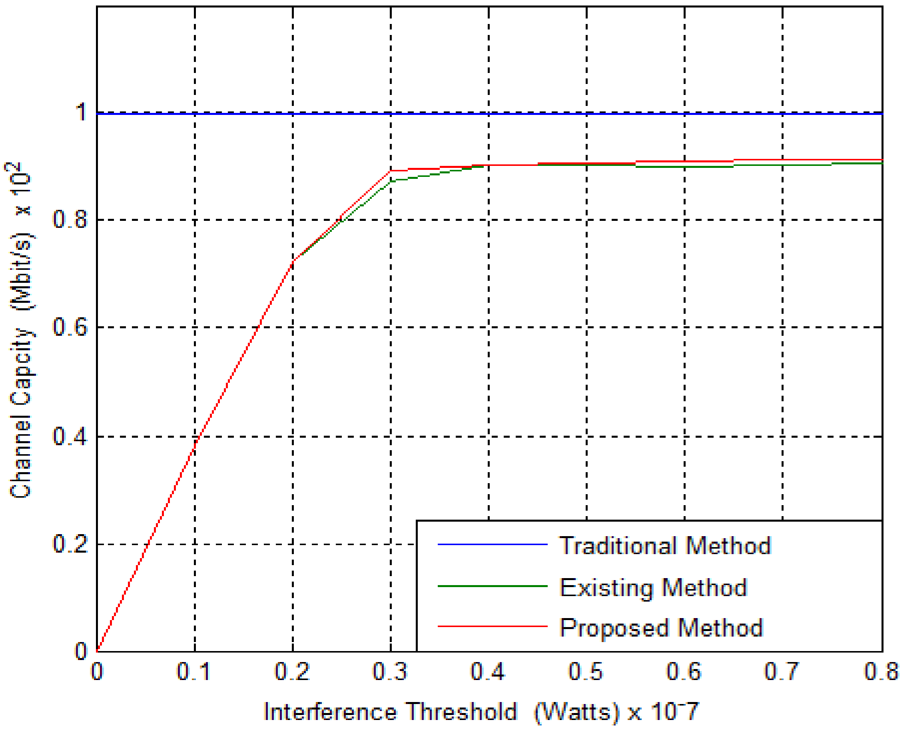

Figure 5. Interference threshold Vs Channel capacity

Figure 4 shows the simulation result of interference threshold versus channel capacity.

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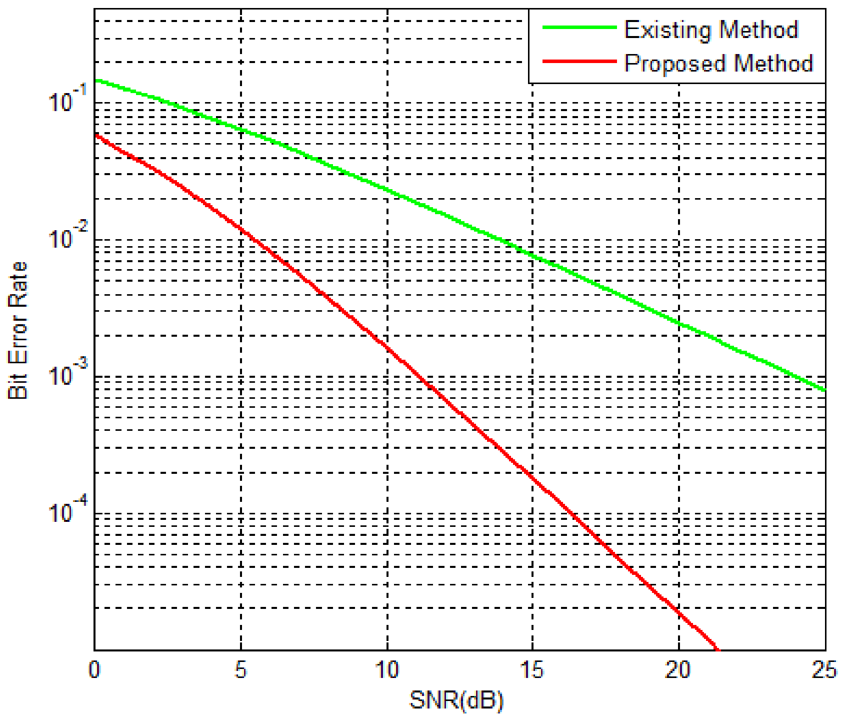

Figure 6. SNR Vs BER

Figure 4 shows the simulation result of signal to noise ratio (SNR) versus bit error rate (BER).

VI. CONCLUSION

From the simulation results we can conclude that, the proposed optimal algorithm provides better performance compared to conventional algorithms which can achieve higher energy efficiency, less bit error rate (BER) and also achieve a good tradeoff between rate channel capacity and interference threshold in cognitive radio networks with low computational complexity. In future work we can extend the same work for increasing Total number of subcarriers N, Total number of Primary Users M, Total number of CR users K and reduced tolerable interference I_{tol}, transmit power P_{max}, and bit error rate with necessary conditions to provide almost near to optimal solutions.

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