ADVANCED ELECTRICAL AND ELECTRONICS ENGINEERING AND SCIENTIFIC JOURNAL
VOLUME1-NO 2- APRIL 2017. WWW.AEEESJ.COM
ISSN: 2520-7539

Minimising of Energy-Consuming of Power Allocation in OFDM-Based Cognitive Radio Systems Using a Modified Water-Filling Algorithm

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Abstract In this work, the water-filling system is proposed to calculate the energy is consuming of power allocation in OFDM-based cognitive radio systems. The conventional water-filling algorithm shows high complexity. To minimise this complexity and to minimise the energy-consuming, a simplified water-filling algorithm is modified. It was evident from extracted results that lowering complexity and minimising the energy-consuming will affect the performance of the system regarding the probability of error mainly. The proposed algorithm can be improved if the secondary multi-carrier system is considered instead of the initial allocation.

***Index Terms*—Energy minimising, OFDM systems, Cognitive Radio, Modified Water-Filling Algorithm**

I. INTRODUCTION

THE transmits power in OFDM systems needs an adaptation to maximise the data rate for multi users. The water-filling policy is one of the successful policies that concerned that results in a real channel gain [1].
In [2], a comparable rate adaptive resource allocation method for Multi-User OFDM (MU-OFDM) is proposed. In this approach, the complexity is reduced to achieve a double capacity of a fixed time division approach. It is evident that the low complexity may lower the power distribution over multi users and have more capacity. However, the price was the increase in the probability of error.
From the other hand, the Peak-to-Average Power Ratio (PAR) in MIMO-OFDM systems also presents a problem that is solved using different approaches and methods [3-8]. In these work, different downlink transmission schemes to reduce the power consumption in the base station.
The performance of the OFDM-Based Cognitive Radio (CR) Systems in [9], standard control algorithms are analysed and compared with the proposed optimal and suboptimal schemes, and numerical results showed higher transmission rate and better performance.
Another strategy is used in [10-11] that aimed to present an optimal strategy to maximise the OFDM-based cognitive radio systems. The traditional water-filling algorithm is applied, and it has been modified for minimising the power in the system,
Now, going back to the water-filling algorithm, we can investigate an energy-efficient algorithm for power

This work was submitted in 3\3\2017 and supported in part by the Electrical Engineering Department in Technological India University.
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allocation to be used for the parallel channel of OFDM system based CR. In this work,

In this work, a modified water-filling (MWF) algorithm will be applied for OFDM based CR through proposing a more efficient algorithm to optimise the power allocation in such systems.

II. CONVENTIONAL WATER-FILLING ALGORITHM

Based on work [12], the power allocation of conventional water-filling (CWF) algorithm, can be expressed as

$$P_*^n = \left(\frac{1}{\lambda} - \frac{N_0}{|h_n|^2} \right)^+ \quad (1)$$

Where λ is the Lagrange multiplier, and h_n is the channel gain for each subchannel with the total power constraint P_{total}. The optimum resolution if the Lagrange multiplier λ satisfies the condition

$$\sum_{n=0}^{N-1} \left(\frac{1}{\lambda} - \frac{N_0}{|h_n|^2} \right)^+ = P_{total} \quad (2)$$

Theoretically, The inverse of the Lagrange multiplier can be watched as a

water level. The water level can be originate by the binary search method [13].

To show the complexity of WFA in the next section, we will see the main properties of WFA. By discovering the properties of the water-filling, we propose a low computational complexity power allocation algorithm which requires performing only a single water filling calculation. This algorithm not only significantly reduces the computational.

III. PROPERTIES OF WFA

In [14], a simple and elegant water filling (GWF) approach is proposed to solve the unweighted and weighted radio resource allocation problems. Unlike the conventional water-filling (CWF) algorithm, it eliminates the step to bargain the water level through explaining a non-linear system from the Karush-Kuhn-Tucker conditions of the target problem. The proposed GWF requires less computation than the CWF algorithm, under the same memory requirement and sorted parameters.

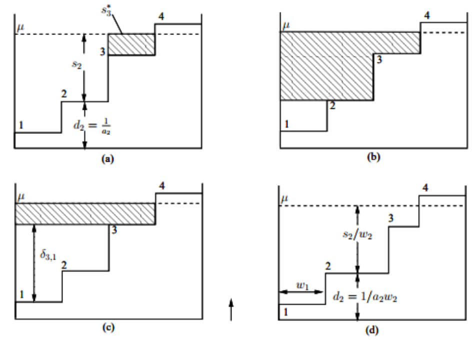

Figure 3.1: Illustration of the Geometric Water-Filling (GWF) algorithm. (a) Illustration of water level step k ∗ = 3, allocated power for the third phase s ∗ 3, and step/stair depth di = 1/ai. (b) Illustration of P2(k) (shadowed area, representing the total water/power above step k) when k = 2. (c) Illustration of P2(k) when k = 3. (d) Illustration of the weighted case [14].

IV. OFDM-BASED COGNITIVE RADIO SYSTEM

The radio spectrum is characteristically a scarce resource, especially in wireless communication networks. Moreover, recent studies have shown that the spectrum is not used optimally and spectrum scarcity is more due to ineffective policies in assigning the spectrum that restricts its use solely to authorised users. A promising approach to solve the spectrum scarcity is cognitive radio (CR) technology that proposes to allocate the spectrum to users dynamically. In CR, secondary users should regularly monitor a predefined frequency band assigned to licensed primary to detect vacant frequency opportunities, commonly referred to as spectrum holes, where this operation is called spectrum sensing [15], [16]. Noticeably, in practice, during the spectrum sensing process, it is essential for secondary users to reliably detect the primary user’s signal to avoid interference from the secondary transmission to the primary network.

However, due to environmental conditions and transmission impairments, the spectrum sensing process is an imperfect process, i.e., its results have some uncertainties.

The Federal Communication Commission (FCC) has recommended geo-location and database access as an another to conventional spectrum sensing for TV band devices (TVBD) to access the accessible channels. However, conventional spectrum sensing is still needed for an optimal usage of the radio spectrum in future applications as suggested by the FCC [17].

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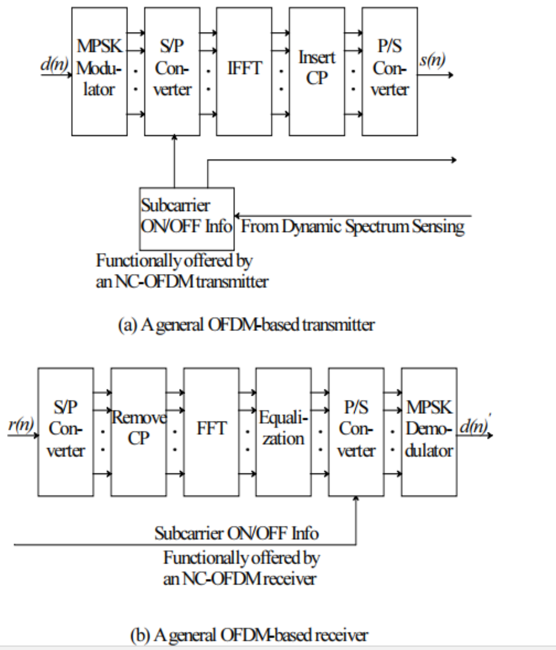

Figure 4.1: A general schematic of an OFDM-based cognitive radio transceiver.

The sidelobes resulting from the use of OFDM for representing the symbols of the low data rate streams are a source of interference to neighbouring transmissions in cognitive radio systems. There are already several techniques exist to suppress this high out-of-band radiation. However, none of them is efficient enough, and new techniques need to be developed to provide further reduction of OFDM OOB radiation.

V. NUMERICAL OUTCOMES

In this section, we extant the Matlab recreation results for OFDM based CR proposed algorithm. We assume the Added White Gaussian Noise (AWGN) noise density N0 and the number of subcarriers, M, For all subcarriers, advantage h_i is assumed self-determining and identically Chi-square distribution. In our simulations, we have a dissimilar number of PUs reaching from 1 to 40. We solution every subchannel with 32 subcarriers so that the total subcarriers variety from 32 to 1280.

The performance of the planned algorithm is evaluated in Fig.5.1. In Fig.5.1, the calculation time for the two kinds of algorithms is plotted. To show the precise increase of the calculation time, we practice the logarithmic rule for the Y axis. It is shown that the calculation time of proposed process is nearly 23 times faster than that of the IPWF algorithm [8].

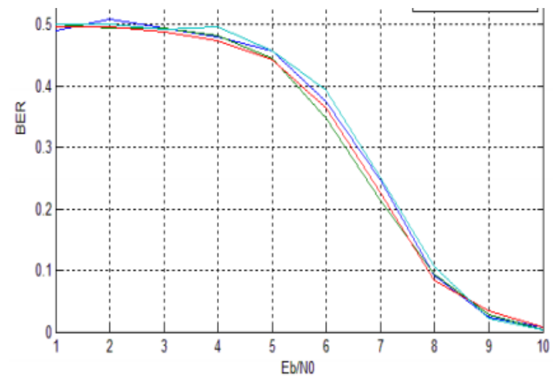

Figure 5.1. Computation time versus numbers of subcarriers for different power allocations

VI. CONCLUSION

In this work, we present different WF systems with the various complexities to minimize the energy consumption of multi-carriers in multicarrier systems. In this work, the water-filling system is proposed to calculate the energy is consuming of power allocation in OFDM-based cognitive radio systems. The conventional water-filling algorithm shows high complexity. To minimise this complexity and to minimise the energy-consuming, a simplified water-filling algorithm is modified. It was evident from extracted results that lowering complexity and minimising the energy-consuming will affect the performance of the system regarding the probability of error mainly. The proposed algorithm can be improved if the secondary multi-carrier system is considered instead of the initial allocation.

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