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An Extensive Review on Peak Cancellation Methods in Wireless OFDM System

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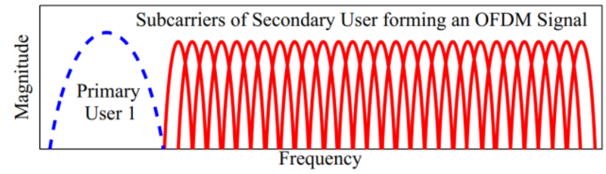
Abstract- The performance of wireless communication systems is mainly governed by the wireless channel environment. As opposed to the typically static and predictable characteristics of a wired channel, the wireless channel is rather dynamic and unpredictable, which makes an exact analysis of the wireless communication system often difficult. In recent years, optimization of the wireless communication system has become critical with the rapid growth of mobile communication services and emerging broadband mobile Internet access services. In fact, the understanding of wireless channels will lay the foundation for the development of high performance and bandwidth-efficient wireless transmission technology. The demand for Radio Frequency (RF) spectrum is increasing consistently with the advent of highly sophisticated wireless technologies. Orthogonal Frequency Division Multiplexing (OFDM) is considered to be suitable for enabling Spectral Pooling because of several reasons such as, in an OFDM system. A variant of OFDM is a Non-Contiguous OFDM (NC-OFDM). NC- OFDM offers an adaptive spectral shape for the secondary user that can coexist with the licensed user without any interference. This examination presents an extensive survey of literature on performance analysis of signal cancellation method on QAM constellations in NC-OFDM.

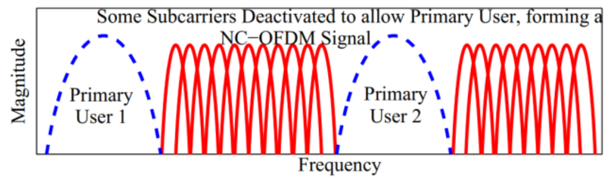
Keywords- OFDM, NC-OFDM, Radio Frequency (RF), Cognitive Radio (CR).

I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) is considered to be suitable for enabling Spectral Pooling because of several reasons such as, in an OFDM system, a series of bits is converted to a number of parallel data streams and each data stream is modulated with different subcarriers which are orthogonally spaced. Due to this parallelism, the symbol rate on each subcarrier is reduced, causing a decrease in sensitivity to intersymbol interference and hence a simple equalizer at the receiver. Such division of spectrum into multiple orthogonal subcarriers makes the system robust to multipath channel fading. Also, a variant of OFDM, Non-Contiguous OFDM (NC-OFDM), can be created by deactivating several subcarriers that are directly responsible for causing OOB emissions resulting in interference. NC- OFDM offers a adaptive spectral shape for the secondary user that can coexist with the licensed user without any interference. The advantages of using OFDM for cognitive radio-based Spectrum Pooling are the flexibility achieved by occupying the spectral gaps in the licensed bands when they are idle, deactivating the subcarriers that are coinciding with the primary user transmissions, the inherent frequency sub-banding, significantly high data rates and tolerance to multipath fading.



(a) Spectrum shared by Primary User and Secondary User.



(b) Secondary User Re-adjusting itself after Primary User's Transmission Overaps it.

Fig. 1.1 concept of NC-OFDM.

Figure 1.1 illustrates the concept of NC-OFDM used for secondary transmissions of Spectrum Pooling. Figure 1.1 (a) depicts the scenario of spectrum shared between licensed and rental users. In this scenario, if a primary user decides to transmit on the frequencies which are currently occupied by rental users, the NC-OFDM signal of the secondary user deactivates its subcarriers to accomodate the primary user. This is shown in the Figure 1.1(b).

One of the key challenges in designing OFDM-based cognitive radio systems for Spectrum Pooling is considered to be the interference caused by the high sidelobe levels. These sidelobes can potentially interfere with the adjacent primary user or even the rental user transmissions. Various researchers across the world have proposed techniques to suppress these sidelobes. As specified in the reference, sidelobes should be suppressed to a power level of -60dB with respect to the OFDM spectrum to achieve adjacent transmissions without any interference.

II. NC-OFDM COGNITIVE RADIO

Cognitive Radio can be termed as a paradigm for wireless communication in which the network or the node itself modifies its transmission or reception parameters to execute its tasks efficiently without causing hinderance to other users operating within the same wireless environment. In other words, a Cognitive Radio System must possess the capability to perform opportunistic access to enable coexistence of primary and secondary users.

Flexible spectrum pooling is made possible by Cognitive Radio (CR) technology, which is an extension of Software Defined Radio (SDR) technology, where the wireless platform rapidly configures its parameters depending upon the current spectral usage and environment. CR is an autonomous unit that intelligently configures its transceiver parameters depending on the environment and the present spectral usage scenario so as to transmit within the spectral gaps. As a result, this process enables the secondary utilization of the licensed spectrum.

Figure 2.1 shows the concept diagram of Cognitive Radio (CR). CR has a SDR, featuring as a radio environment. A CR senses the spectrum using SDR analyses the spectrum and finally changes its transceiver parameters accordingly. An important issue in achieving efficient DSA is detecting a idle spectral range and transmitting in that spectral gap without interfering with the neighboring transmissions. This can be achieved with the help of Software Defined Radio (SDR).

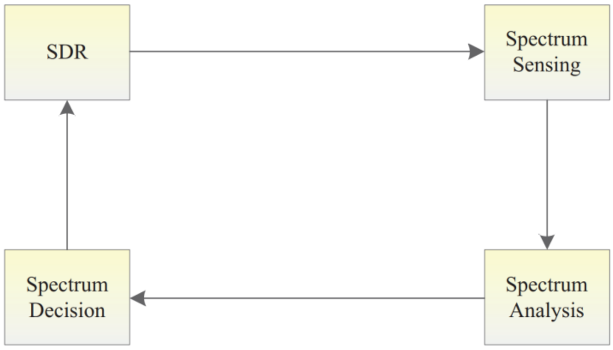


Fig. 2.1A concept diagram of cognitive radio (CR) showing the basic procedure per- formed by CR.

In a conventional radio, various communication subsystems such as filters, modulators, demodulators, and amplifiers are implemented in hardware. As a result, it fails to provide any flexibility. Conversely, Software Defined Radio (SDR) is a radio communication system where the communication subsystems are implemented by means of software on a computer or an embedded system. A SDR usually consists of a processor, an Analog-to-Digital Converter (ADC), a Digital-to-Analog Converter (DAC) and a RF front end. Based on the same hardware, different transmitter/receiver algorithms are implemented in software. Thus, SDR provides a large amount of flexibility compared to the conventional radio.

III. PRIOR WORK

SR. NO.	TITLE	AUTHOR	YEAR	APPROACH
1	Performance analysis of signal cancellation method on QAM constellations in NC-OFDM	B. K. Jeemon, S. B. Prasad and S. Dhanya,	2017	Sidelobe suppression and PAPR reduction problem is a quadratically constrained quadratic program (QCQP) in this examination.
2	Sidelobe power and PAPR reduction for CR systems with NC-OFDM,	M. Hao and L. Chen,	2017	A novel method is reported for jointly reducing sidelobe power of signals in licensed user bands (LU) and PAPR for the CR system with the NC-OFDM scheme
3	Physical-layer security of NC-OFDM-based systems	G. Sridharan, R. Kumbhkar, N. B. Mandayam, I. Seskar and S. Kompella,	2016	This work examines the low-probability-of-exploitation (LPE) characteristics of a noncontiguous orthogonal frequency division multiplexing (NC-OFDM) system
4	In-Band-Interference Robust Synchronization Algorithm for an NC-OFDM System	P. Kryszkiewicz and H. Bogucka,	2016	A novel preamble-based synchronization algorithm for estimation of the time and frequency offset based on the received signal cross-correlation with the reference preamble has reported in this work.
5	Joint PAPR Reduction and Sidelobe Suppression Using Signal Cancelation in NC-OFDM-Based Cognitive Radio	C. Ni, T. Jiang and W. Peng,	2015	A novel signal cancellation (SC) method for joint PAPR reduction and sidelobe suppression in NC-OFDM-based CR systems has reported in this examination

	Systems,			
6	Precoding for PAPR reduction and sidelobe suppression for NC-OFDM based cognitive radio systems	M. Hao and C. Lai,	2015	Reported a precoding scheme to jointly reduce PAPR values in the secondary users (SUs) spectrum band and suppress sidelobes of signals in the primary user (PU) band.
7	Energy-efficient NC-OFDM/OQAM-based cognitive radio networks,	T. Jiang, C. Ni, D. Qu and C. Wang	2014	Proposed key idea of the criterion is to jointly reduce the PAPR and suppress the sidelobe in NCOFDM/ OQAM-based CR systems.
8	Evaluation of influence by simultaneous reception of other radio systems in wideband NC-OFDM,	K. Kosaka, K. Takakusaki, I. Kanno, A. Hasegawa, H. Shinbo and Y. Takeuchi,	2014	This examination evaluate the influences in a WNC-OFDM receiver by developed experimental equipment and computer simulations

B. K. Jeemon, S. B. Prasad and S. Dhanya, [1] Non-contigious orthogonal frequency division multiplexing (NC-OFDM) is an emerging field in cognitive radio (CR) systems. Large sidelobe power and high peak power (PAPR) are major shortcomings of this system at the transmitter end. To jointly reduce both these parameters, the signal cancellation (SC) method is used here. Sidelobe suppression and PAPR reduction problem is a quadratically constrained quadratic program (QCQP) and solved using the CVX software. This method concentrates on joint optimization for reducing power of sidelobe and peak power by adding cancellation signal on primary user subcarrier and extending constellation points on secondary user subcarrier. This examination focuses on the performance analysis of signal cancellation method on different QAM constellations.

M. Hao and L. Chen,[2] The non-continuous orthogonal frequency division multiplexing OFDM (NC-OFDM) based cognitive radio (CR) system has many advantages but also suffers from the problems of high peak-to-average power ratio (PAPR) and large sidelobe power of the transmission signals. In this exploration, a novel method is proposed for jointly reducing sidelobe power of signals in licensed user bands (LU) and PAPR for the CR system with the NC-OFDM scheme. A method to construct a precoding matrix for reducing PAPR values by choosing a proper shaping pulse is developed first. A replacement procedure through the singular value decomposition (SVD) is executed to modify the precoding matrix for further achieving the minimum bit error rate (BER) performance. Second, two pseudo random sequence assignment algorithms, the Random Circular Sequence (RCS) and Quadratic Permutation Polynomials (QPP) algorithms, are proposed in the Multiple Choice Sequences (MCS) scheme for suppressing sidelobe power of signals in LU bands. Both algorithms have low complexities in computation and are easy to perform with only requiring a small amount of side information. Simulation results show that, by combining the optimum precoding matrix with the MCS procedure, decreasing the PAPR values and sidelobe power of signals in LU bands can be achieved simultaneously. Without introducing signal distortion, the proposed algorithms have better effects in sidelobe power suppression than the phase approach, and almost the same performance as the random assignment method.

G. Sridharan, R. Kumbhkar, N. B. Mandayam, I. Seskar and S. Kompella, [3] This work examines the low-probability-of-exploitation (LPE) characteristics of a noncontiguous orthogonal frequency division multiplexing (NC-OFDM) system. NC-OFDM transmission is similar to OFDM transmission but only uses a subset of the frequencies either to avoid incumbent transmissions or due to tactical considerations. This exploration considers an NC-OFDM transmission with a given set of active subcarriers and examines how an eavesdropper can infer transmission parameters such as total duration of an NC-OFDM symbol, length of the cyclic prefix, etc., using tools like the cyclostationary analysis. Such an analysis reveals that difficulty in estimating the total nominal bandwidth of NC-OFDM transmissions (bandwidth that includes frequencies occupied by inactive subcarriers) poses a fundamental challenge in determining the correct sampling rate and the subsequent retrieval of the transmitted signal. The analysis also shows that the features of the cyclic autocorrelation function (CAF) of an NC-OFDM transmission depend closely on the set of active subcarriers. Procedures for inferring the transmission parameters from the CAF are discussed while noting that the choice of an interleaved set of subcarriers introduces additional ambiguity in determining the transmission parameters. A PCA-based offline timing recovery scheme is proposed and used as a guidepost in determining the minimum rate at which an active set of subcarriers must be refreshed to avoid easy exploitation. Finally, key advantages of an NC-OFDM system over an OFDM system from an LPE-standpoint are discussed and suggestions for an LPE-centric design of NC-OFDM systems are made.

P. Kryszkiewicz and H. Bogucka, [4] This work consider receiver synchronization in the non continguous orthogonal frequency division multiplexing (NC-OFDM)-based radio system in the presence of in-band interfering signal, which occupies the frequency-band between blocks of subcarriers (SCs) used by this system, i.e. in-band of NC-OFDM receiver spectrum range. This examination work proposes a novel preamble-based synchronization algorithm for estimation of the time and frequency offset based on the received signal cross-correlation with the reference preamble. Contrary to the existing algorithms, it is robust against in-band interference including narrowband interference at the cost of increased complexity. Moreover, in the interference-free system, the probability of frame synchronization error is improved in comparison to all simulated algorithms.

[C. Ni, T. Jiang and W. Peng, [5] It is well known that the high peak-to-average power ratio (PAPR) and large spectrum sidelobe power are two main drawbacks at the transmitter in noncontiguous orthogonal frequency-division multiplexing (NC-OFDM)-based cognitive radio (CR) systems. In this work, propose a novel signal cancellation (SC) method for joint PAPR reduction and sidelobe suppression in NC-OFDM-based CR systems. The key idea of the proposed method is to dynamically extend part of the constellation points on the secondary user (SU) subcarriers and add several SC symbols on the primary user (PU) subcarriers to generate the appropriate cancellation signal for joint PAPR reduction and sidelobe suppression. Then, the SC method formulates the problem of the joint PAPR reduction and sidelobe suppression as a quadratically constrained quadratic program (QCQP) to obtain its optimal cancelation signal. Moreover also propose a suboptimal SC (sub-SC) method to efficiently solve the QCQP optimization problem with low computational complexity. Simulation results show that the proposed SC method and the sub-SC method can provide both significant PAPR reduction and sidelobe suppression performances.

M. Hao and C. Lai, [6] The non-contiguous orthogonal frequency division multiplexing (NC-OFDM) based cognitive radio (CR) system has the drawbacks of high sidelobe power and peak-to-average power ratio (PAPR) values. A precoding scheme to jointly reduce PAPR values in the secondary users (SUs) spectrum band and suppress sidelobes of signals in the primary user (PU) band HAS reported. First, a precoding matrix according to the chosen pulse shape is established for reducing PAPR values. A systematic procedure is developed, which includes the singular value decomposition (SVD) and reconstruction process to generate the PAPR reduction matrix at the minimum error rate. To maintain the PAPR performance and avoid interferences in PU spectrum band, an algorithm searching the optimum precoding matrix is determined. Finally, with the Matrix for reducing the PAPR value and the sidelob suppression matrix, reconstruct the precoding matrix such that the PAPR reduction in the SU band and sidelobes suppression performance in the PU band is accomplished concurrently. Simulation results show that our scheme has excellent performance.

T. Jiang, C. Ni, D. Qu and C. Wang, [7] With the explosive growth of wireless multimedia applications and the demand for high data rate, improving the spectrum and energy efficiencies have been two most critical challenges for wireless communication networks under the background of limited spectrum and energy resources. Cognitive radio and OFDM/OQAM have emerged as two exciting technologies to solve the spectrum scarcity in future cellular networks; thus, energy-efficient communications have attracted increasing attention in cognitive radio networks. In this article, consider how to make an energy-efficient physical layer design for non-contiguous (NC) OFDM/OQAM-based cognitive radio networks. Specifically, reported a criterion on how to reduce the high PAPR of NC-OFDM/OQAM signals to achieve high power efficiency. The key idea of the proposed criterion is to jointly reduce the PAPR and suppress the sidelobe in NCOFDM/ OQAM-based CR systems. Extensive simulation results verify that the proposed criterion can provide both significant PAPR reduction and sidelobe suppression, resulting in prominent improvement of energy efficiency in NC-OFDM/OQAM-based cognitive radio networks.

K. Kosaka, K. Takakusaki, I. Kanno, A. Hasegawa, H. Shinbo and Y. Takeuchi,[8] this work studying Wideband Non-Contiguous OFDM (WNC-OFDM) to utilize unused frequency bands. WNC-OFDM achieves high-speed communication by gathering OFDM subcarriers on the unused frequency resources that are located dispersively and narrowly in extremely wide bands. In this case, since a WNC-OFDM receiver receives not only the desired WNC-OFDM signals but also undesired signals of other systems simultaneously, WNC-OFDM signals are affected by the interference from the signals of other radio systems. It is important to comprehend the influences from other radio systems and tolerance for them to design and tune WNC-OFDM transceivers. In this examination, evaluate the influences in a WNC-OFDM receiver by developed experimental equipment and computer simulations.

IV. PROBLEM IDENTIFICATION

One of the major roadblocks in designing new wireless communication standards is the issue of whether the current spectrum availability allows for the usage of transmission specifications as desired by the standard. The available Radio Frequency (RF) spectrum is scarce and new emerging wireless technologies should try to achieve the best performance under given bandwidth constraints.

Growing adoption of applications that consume large amounts of available bandwidth resulting from their data-intensive content, such as online streaming music and video applications is also responsible for the increasing demand for RF spectrum. One of the key challenges in designing OFDM-based cognitive radio systems for Spectrum Pooling is considered to be the interference caused by the high sidelobe levels. These sidelobes can potentially interfere with the adjacent primary user or even the rental user transmissions. Various researchers across the world have proposed techniques to suppress these sidelobes. As specified in the reference, sidelobes should be suppressed to a power level of -60dB with respect to the OFDM spectrum to achieve adjacent transmissions without any interference. Prior work discussed the frequency domain cancellation carrier technique for OFDM transmissions, wherein a few subcarriers with different weights are added on either side of the OFDM spectrum to negate the existing sidelobes.

V. CONCLUSION

An extensive review on performance analysis of signal cancellation method in NC-OFDM has reviewed in this examination based on prior work. The ever increasing demand for very high rate wireless data transmission calls for technologies which make use of the available electromagnetic resource in the most intelligent way. Key objectives are spectrum efficiency (bits per second per Hertz), robustness against multipath propagation, range, power consumption, and implementation complexity. These objectives are often conflicting, so techniques and implementations are sought which offer the best possible tradeoff between them. The Internet revolution has created the need for wireless technologies that can deliver data at high speeds in a spectrally efficient manner. However, supporting such high data rates with sufficient robustness to radio channel impairments requires careful selection of modulation techniques.

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