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# Implementation of Optimization Algorithm by Sub-Carriers Assignment and Power Allocation for LTE and Cognitive Radio Network using OFDM Signal

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**ABSTRACT**

*The optimization algorithm had been analysed for the improvement of the spectrum efficiency and check trade-off between capacity and fairness for cognitive networks in a low algorithm complexity. Different low complexity algorithms for proportional resource allocation in Long Term Evolution (LTE) and Cognitive Radio Network (CRN) using OFDM signal are used by different researchers already. Here, the target of the optimization algorithm is to provide the sub-carriers assignment and power allocation for each user, assuming that the modulation type is the same for all subcarriers. However, in order to increase the efficiency of the algorithm and reduce the optimization delay, it had been assumed that the power is equally distributed among the sub-carriers.*

**Key words:** Long Term Evolution (LTE), Cognitive Radio Network (CRN), Orthogonal Frequency Division Multiplexing (OFDM), RRM, D2D Technology

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## INTRODUCTION

### What are CRN?

Cognitive Radio (CR) is a form of wireless communication in which a transceiver can intelligently detect which communication channels are in use and which are not, it can immediately move into vacant channels while avoiding occupied channels. Cognitive Radio Network (CRN) has been widely investigated to increase the spectrum utilization in communications area. Nowadays, the dual-use of radar/sensing and communications system is also exploited. Many investigations on the convergence of the wireless sensor network and the communications system based on the cognitive radio network are done as it is quite beneficial in this technical world [1]-[14]-[15]. As Orthogonal Frequency Division Multiplexing (OFDM) signal is inherently fit with the CRN, the dual-use of the OFDM system and radar/sensing system has become an important part of modern network [16].

### LTE Systems

As a major part of mobile social networks, LTE systems support a great number of mobile social contact services. An important feature of social networks is the need of the same traffic contents by more than one terminal [2]. Therefore, wireless multicast has the potential to support mobile social contacts because of its outstanding resource efficiency for transmitting packets from a single sender to multiple receivers at almost the same wireless resource as unicast [3-17]. However, wireless multicast performance is restricted by the terminal with the worst channel condition. Be aware of the scarce spectrum resource, resource allocation for wireless multicast is still open for more investigation.

### OFDM

A typical OFDM consists of a transmitter and receiver structure. A transmitter includes a baseband modulator, subcarrier mapping, inverse Fourier transform cyclic prefix addition, parallel-serial conversion, and a digital-to-analog converter followed by an I-Q radio frequency modulator. OFDM transmits a block of data symbols simultaneously over one OFDM symbol [2]-[4]-[18]. An OFDM symbol is the time used to transmit all of subcarriers that are modulated by the block of input data symbols. The baseband modulator transforms the input binary bits into a set of multi-level complex numbers that corresponds to different modulations formats such as Binary Shift Keying (BPSK), Quadrature phase Shift Keying (QPSK), 16- or 64-Quadrature Amplitude Modulation (QAM).A typical OFDM receiver includes an Radio Frequency (RF) section, Analog to Digital Converter (ADC), parallel-to-serial converter, cyclic prefix remover, Fourier transformer, sub-carrier de-mapper, equalizer and detector [5].

Tang et al [6], proposed an optimized model for joint spectrum allocation and scheduling is proposed with the condition of interference characterization of Multi-Channel Contention Graphs to increase the throughput achieved by Secondary Users (SUs) in a multi-hop cognitive radio network. In [7], Zang et al proposed an OFDM-based CR system with one or more spectrum holes existing among the multiple Primary Users (PUs) frequency bands is considered. Subcarrier and power allocation optimization is formulated as a multi-dimensional 0-1 knapsack problem (MDKP) and a greedy max-min algorithm is proposed to solve it. Two distributed algorithms to optimally allocate subcarriers and power in OFDMA is proposed By Ngo et al [9]. Ad hoc CRN have been proposed to offer either throughput maximization or energy efficiency subject to tolerable interference introduced to the primary network, and a joint subcarrier and power allocation method has been derived by Lagrange dual algorithm to maximize the capacity of the cognitive radio networks. Zing et al [10] proposed a statistically robust resource allocation scheme for a decode-and-forward relay-assisted OFDMA network with imperfect channel state information has been proposed in maximizing the sum rate of the overall network while solving the problem of the power leakage between neighbouring subcarriers. However, the problem of resource allocation in cognitive multicast networks with device to device communication under imperfect sensing condition is still open for more investigation [9].

Chang [11] proposed OFDM is a special type of Multicarrier Modulation, where the data stream is divided into multiple bit streams and is modulated using closely spaced non-interfering frequencies called subcarriers. In conventional Frequency Division Multiplex systems, a band-pass filter is used to filter to limit the bandwidth of the transmission or reception. In OFDM, instead of using sharp cut-off filters, an Inverse Fast Fourier Transform (IFFT) is used to convert the frequency data carrying subcarriers to a time domains signal which can be up converted to the desired carrier frequency. An inverse operation at the receiver using Fast Fourier Transform (FFT) reveals the frequency domain information. Al Qerm et al [12] proposed that our integrated cognitive scheme with CogWnet is an efficient solution for LTE networks. It is general cognitive radio architecture that is integrated with throughput and interference management model to improve efficiency in LTE networks. CogWnet is designed for high abstraction control functions and general tasks. Our overall system goal was to optimize spectrum allocation, mitigate interference, maximize throughput and reduce complexity. Radio environment awareness and optimization algorithms are used to improve network efficiency and respond to changes in network conditions. Optimization starts with receiving periodic channel information. Traffic load and Power Estimation Ratio (PER) were used to tune modulation, power, frequency, and bandwidth [8].

The software radio network platform based on a hybrid implementation of 802.11 physical layers using general purpose CPUs and a radio control board is proposed by Yu et al [13]. Although most of the transceiver chain is implemented in software, the system is currently not able to support Non Contiguous-OFDM (NC-OFDM) transmission and reception, which is the basic requirement for the cognitive radio environment. Software Radio Network (SRN) uses various cache optimization techniques and core dedication for specific functionalities, which might require redesigning for a wider bandwidth CR.

## MATERIALS AND METHODS

### Optimization Algorithm and Parameter Analysis

The main purpose of the optimization algorithm is to use the CR for the sub-carriers assignment and power allocation for each user [19-21]. When using this algorithm, we have assumed that the modulation type is the same for all subcarriers. In the optimization algorithm, we have make use of the standard parameters to analyze the fairness by defining a lower bound of allowable number of subcarriers allocated to the radio network. The optimization algorithm is analyzed for the improvement of the spectrum efficiency. We have analyzed the trade-off between capacity and fairness for cognitive networks while keeping low algorithm complexity.

However, in order to increase the efficiency of the algorithm and reduce the optimization delay and the power is equally distributed among the sub-carriers. This solution set for each user is necessary in order to calculate the data rate that each user will experience. For the practical purposes, it is assumed that all sub-carriers are modulated with 16-QAM modulation type (4 bits/symbol). Taking into account the symbol length for LTE systems, which is 66.7μs, the data rate per sub-carrier is 60Kbps. There is a link-layer capability that specifies the maximum constant arrival rate the system can support subjected to a given Quality of Service (QoS) requirement [1].

**Implementation**

The convergence of the wireless sensor network to CRN is increasing day by day due to its efficiency. The goal of the conceptual design is to utilize the key features of the CRN as possible as it can, like the efficient spectrum utilization, software defined radio, etc. Although the technology of this network is based on the single transmitter and receiver, it still unveils the big potential of large scale wireless sensor network based on the CRN. With the help of LTE and CRN, it is possible to use signals for detection of non-contiguous spectrum as allocated to the secondary user. The receiving energy can be calculated based on such spectrum. The OFDM has visible relationship with the target position and the amplitude based detection where localization is practical when deploying the CRN.

The real OFDM signal needs to be implemented to find more issues of real cognitive radio and more algorithms are required which are not only based on the amplitude but which are based on theories like optimization and machine learning. These can be introduced to improve the capability or performance of the target sensing. The collaboration and synchronization for the data collection at different nodes will also have some impact on the overall performance in the CRN.

**Methodology Used**

In the earlier research on the similar topics, a low complexity algorithm for proportional resource allocation in LTE and CRN using OFDM signal is used. Here, the target of the optimization algorithm was to provide the sub-carriers assignment and power allocation for each user, assuming that the modulation type is the same for all subcarriers. However, in order to increase the efficiency of the algorithm and reduce the optimization delay, it had been assumed that the power is equally distributed among the sub-carriers.

In this paper, a joint subcarrier and power allocation method for CRN using OFDM signal. The impact of imperfect spectrum sensing is considered in the proposed problem, which had been studied for capacity decrease of the LTE using CRN. In the optimization algorithm, the fairness is analysed by defining a lower bound of allowable number of subcarriers allocated to the radio network. The optimization algorithm is analysed for the improvement of the spectrum efficiency and check trade-off between capacity and fairness for cognitive networks in a low algorithm complexity.

## RESULTS AND DISCUSSIONS

In this paper, we will show and discuss all of the results obtained by the computer simulation program written in Matlab7. In this research paper, CR functionalities for LTE systems using OFDM access technology are studied. CR enhanced with context matching methods are capable not only to learn from earlier optimizations that the management configuration performed in the past but also to take care and identify the same or similar contexts and use known solutions leaving aside the optimization procedures.

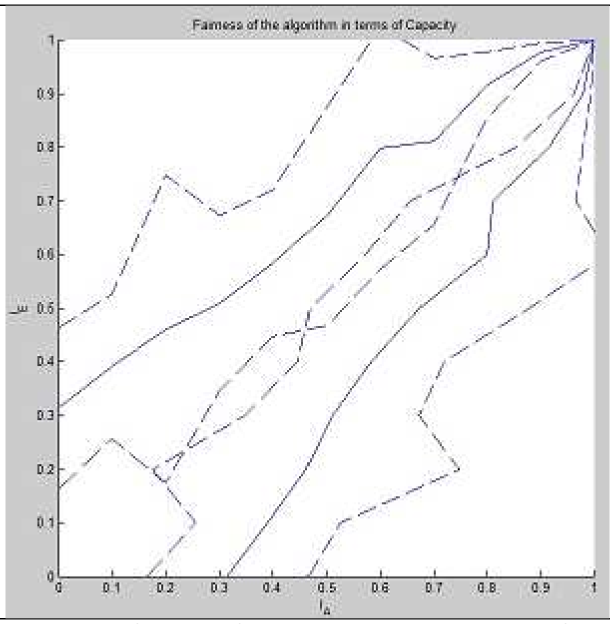


**Fig. 1 Performance of cognitive radio network in terms of impedance factor**

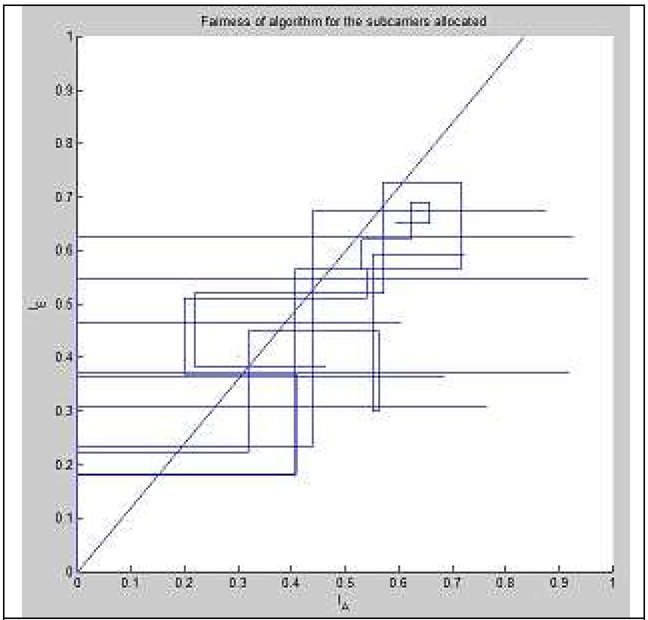


**Fig. 2 Capacity and fairness for cognitive networks**

Our further research procedure tries to find out high level information that is learned by the CR in order to apply that in the future independently of the communication system we are using. CR system performs even better if there are a number of optimization procedures that take place for each one of the systems separately. It is also possible to predict traffic cases using CR in the service area using timestamps parameters. So, it is possible for the CR system to predict future problems and apply the corresponding solutions before the problematical situations actually occur.

In Fig. 1, desired radio waveform at the transmitter is generated. The MATLAB code is designed for imperfect spectrum sensing which was considered in the proposed problem. This figure is used for studying the capacity decrease of the LTE based CRN. Our goal is to generate baseband multi-frequency signal with proper input parameters for the subcarriers considered. The bandwidth of the used signal is 10MHz which contains 64 subcarriers.

Here, subcarriers which are based on five zones in the CRN are studied. We have assumed a static load pattern in the service area where the Signal to Noise Ratio (SNR) for the users of each zone depends mainly on the distance of each zone from the centre of the subcarrier. In fig. 2, for independent subcarriers, it is considered that the $I_A$ value will be above of the minimum threshold in order to check that the users will be able to experience services close to the basic quality of service level. According to our exploration, 50% of the users are randomly distributed in the service area in radio cognitive network. While using the optimization algorithm, the fairness is analyzed by defining a lower bound of allowable number of subcarriers allocated to the cognitive radio network.

The optimization algorithm is implemented and its performance is analyzed for the improvement of the spectrum efficiency and check trade-off between capacity and fairness for cognitive networks in a low algorithm complexity. However, the change in parameters is not large enough but still we have tried and tested the parameters so that we can get results based on the solution which is provided by the optimization module.

## CONCLUSION

This paper presents the vision and challenge for the implementation and simulation of the wireless sensor network to CRN. The goal of the conceptual design is utilize the key features of the cognitive radio network as possible as it can, like the efficient spectrum utilization, software defined Radio etc. Although the simulation is based on the single transmitter and receiver, it had shown the big potential of large scale wireless sensor network based on the CRN.

The signal used for detection is based on complete spectrum as allocated to the secondary user. The receiving energy, calculated based on such spectrum has visible relationship. Vision of the future large scale of wireless sensor network based on CRN with the target position, i.e, the amplitude based detection and localization is practical when deploying the wireless sensor network. The simulation architecture of cognitive radio network is presented.

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