© 2017 IJSRST | Volume 3 | Issue 8 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Survey on Optimization Techniques used for Resource Allocation in Wireless Communication System

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ABSTRACT

In recent years telecommunication is playing a major role in the field of communication. In wireless communication systems, the necessity to provide more number of users with high-rate communication links leads to optimization problems. Demands of resource block assignment, interference and power consumption at base station and mobile devices have to be answered in the face of time-varying frequency-selective channels. In addition, the heterogeneity of recent mobile services means that delay and data rate requirements vary significantly between applications and users. These requirements are summarized as resource allocation problems.
Keywords: Optimization, Resource Allocation, Orthogonal frequency Division Multiplexing.

I. INTRODUCTION

The design of wireless systems in the presence of fading involves the instantaneous allocation of resources such as power and frequency with the crucial goal of existing long term system properties such as ergodic capacities and average power consumptions [3, 5]. This makes a unique problem structure where long term average variables are determined by the expectation of a not essentially concave functional of the resource allocation functions. This paper explains the modeling, analysis and solving of resource allocation problems. As the combination of these problems is computationally prohibitive, the development of approximation techniques and algorithms plays a vital role.

By combining results from integer, convex and non-convex optimization theory, performance estimates and bounds for these approaches can be derived. A challenge toward wireless communications is to maximize energy efficiency by optimally allocating wireless resources in large-scale multiuser multicarrier orthogonal frequency-division multiple-access (OFDMA) systems. The quality of- service (QoS) - constrained energy efficiency maximization problem is generally hard to solve due to the inverse transposition of the optimization operands in the optimization objective. We apply convex relaxation to make the problem quasiconcave with respect to power and concave with respect to the subcarrier indexing coefficients.

Meanwhile, spectral efficiency (SE) has been the main performance indicator for the design and optimization of wireless communication systems.

II. Orthogonal frequency division multiple access (OFDMA)

OFDM is a mixing of modulation and multiplexing. It is commonly adopted by all major (4G, 5G) wireless communication systems, energy-efficient designs of OFDMA systems are critical toward wireless communication systems. The energy efficiency spectral-efficiency (EE–SE) relation is showed to be quasi concave , revealing the presence of a tight lower bound and a tight upper bound on the EE–SE curve, which were obtained by using Lagrangian dual decomposition[6,8]

The EE resource allocation problem under consideration is a mixed combination and non-convex optimization problem, which is extremely difficult to solve. In order to reduce the computational complexity, we decompose the original problem with multiple inequality constraints into multiple optimization problems with single inequality constraint [9, 10].

2.1 Resource Allocation Algorithm

Initially an optimal solution is developed based on the second order cone programming. Since the complexity of convex programming is comparably high, an upper-bound near-optimal solution based on the uplink-downlink duality is proposed. To further reduce the computational complexity, a suboptimal solution based on ZF precoder is proposed. To harvest the potential advantages of Virtualized Wireless Network (VWN), effective resource allocation is a major concern, which has been representing a lot of attention in recent years.[3] By applying the outline of complementary geometric programming (CGP) and successive convex approximation (SCA) an efficient, iterative, two-step algorithm is developed to solve the proposed problem. Energy efficiency optimization belongs to a class of optimization problems called fractional programs. In an effort to investigate solutions of fractional programs, a fractional programming framework is proposed, which solves the energy efficiency problem effectively by transforming the objective into a weighted sum of rate and power. As the rate is a concave function of the transmit power, the framework is optimized by applying dual Lagrangian which provides solutions for large class of energy efficiency problems under various system models. By manipulating the properties of fractional programming, some recent works expanded their system modeling to propose solutions considering cognitive radio, relay networks, and MIMO technology.[11]
Inorder to maximize the QoS aware energy efficiency performance of multiuser multicarrier OFDMA systems, simple convex optimization approach using Maclaurian series expansion technique is used to transform the complex transcendental functions into simple polynomial expressions. It allows to obtain the global optimum solution in fast polynomial time with tractable upper bound of truncation error. With the new solution method, a joint optimal subcarrier and power allocation policy is proposed.[8]

III. Energy Efficiency and Spectral Efficiency

Recent research has focused on improving communication techniques by adopting the energy efficiency as a performance metric. Energy efficiency is defined as the ratio of two real-valued functions, which are measured in "throughput per Joule," and it is subject to the radio resource management and the power consumption at the electrical circuits. According to the earlier study reports, there is no work in the literature focusing on jointly optimizing EE and SE in an uplink of multi-user two-tier HetNets considering the cross-tier interference limitations and providing users' QoS in terms of minimum rate requirements and maximum transmission power constraints. In this paper, formulation of an MOP framework for joint power allocation and subcarrier assignment for EE-SE tradeoff under maximum transmission power constraints is provided when satisfying a rate QoS requirement in two-tier HetNets. The proposed multi-objective framework jointly performs power allocation and subcarrier assignment while optimizing the two conflicting objectives, namely, EE and SE. Transformation of the formulated MOP into a single-objective optimization problem (SOP) using a weighted sum method is done to prove that the formulated SOP is strictly quasi-concave with respect to the transmit power, thereby deriving an unique optimal solution. By exploiting the fractional programming concepts, the SOP problem can be transformed into an equivalent subtractive form which is tractable in nature. Then, an iterative two-layer solution combining Dinkel bach type method and Lagrangian dual decomposition approach is proposed to solve the formulated SOP.

In this design a resource allocation algorithm for downlink of orthogonal frequency division multiple access (OFDMA) systems supporting real-time (RT) and best-effort (BE) services simultaneously over a time-varying wireless channel.

The optimization problem representing the resource allocation can be solved by using the dual optimization technique and the projection stochastic sub gradient method. The distinctive feature of the proposed algorithm is the restriction on average absolute deviation of transmission rate (AADTR), which is introduced to provide stable transmission rates to the Real time users. We have formulated the optimization problem, and developed the algorithm that solves it by the dual optimization techniques. It is shown by the simulation that the proposed algorithm meets well its design goal and outperforms M-LWDF in terms of the packet drop rate of the RT users and the throughput of the BE users.

To study the EE maximization problem by taking into account the individual user QoS. Furthermore, each user is also equipped with some initial energy, which may be the energy left from the previous transmission blocks or harvested from other sources, such as solar and wind. These setups enable users to have higher flexibility in utilizing energy and also make the considered problem more general than the previous works. The joint impact of spectral bandwidth, power, and code rate is considered. Analytical expressions for the probability of buffer overflow, its associated exponential decay rate, and the effective capacity are obtained. Fundamental performance limits for Markov wireless channel models are identified. It is found that, even with an unlimited power and spectral bandwidth budget, only a finite arrival rate can be supported for a QoS constraint defined in terms of exponential decay rate.

3.1 Ordinal Optimization

Ordinal Optimization (00) is a new optimization theory introduced by Ho in the 90s for providing fast Good enough solutions for complex simulation based optimization problems. It has been applied to solve many problems in different disciplines such as power systems, communication networks, topology design in computer networks, resources allocation in manufacturing systems, scheduling of parallel computing systems, and robotics motion control systems. Ordinal optimization tries to overcome difficulties in existing optimization theories in solving problems that has exponential growth in its search space and computational complexity in its simulation models. Ordinal Optimization is based on two main concepts: 1) Order Comparison: it is easier to determine order than value, i.e. determining A < B is easier than determining the value of A+ B=?

2) Goal Softening: instead of looking for the best , look for good enough with high probability. Using these two concepts, ordinal optimization methods provide a set of Good Enough solutions in an order of their performance.

3.2 NOMA systems

By applying NOMA (Non-orthogonal Multiple Access) on OFDM systems can enhance the spectral efficiency as well as accommodate more users when compared to the conventional OFDMA systems .Like OFDMA systems, dynamic resource allocation will heavily impact the performance of OFDM-NOMA systems. The symbols are transformed into an OFDM symbol by adding inverse fast Fourier transform (IFFT) and cyclic prefix (CP). Here due to CP the influence of multipath fading can be eliminated.

IV. Adaptive Resource Allocation (ARA) for Cognitive Radio Network

ARA is one of the most effective method to improve the spectral efficiency and has been investigated in the last decade. Unlike existing wireless communication networks, the ARA problem in Cognitive Radio Networks is more challenging. First, the detection errors of spectrum sensing which greatly affects the performance of ARA algorithm. A particle swarm optimization (PSO) - a population based heuristic algorithm is proposed to solve the two unconstrained problems.

Table 1 : Comparison of various methods for Resource allocation of different OFDM system

Optimization Techniques	Subcarriers Used (in numbers)	Bandwidth and Power allocated	SNR
MOPSO	72/128	1.4 MHz	2dB
Two –user OFDM	32	320KHz	8dB
OFDM based NOMA system – Deletion based Algorithm	64	15KHz	-
OFDM: Fuzzy Rule based system and PSO	52 Subcarriers	0.7 mW	17.5dB

In table 1 comparison has made on Resource allocation for OFDM systems and resources considered are subcarriers, bandwidth , SNR and power.

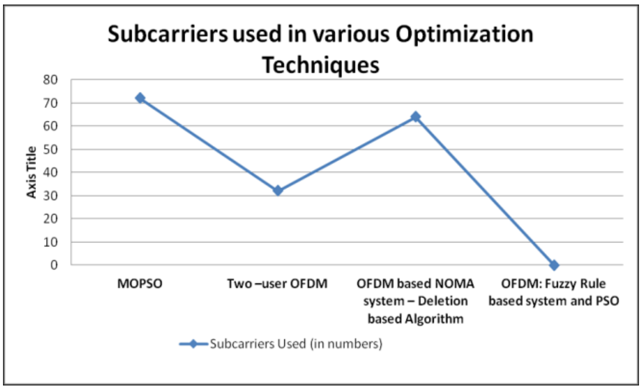

Fig- 3.1(a) Comparison of number of subcarriers used in various optimization techniques.

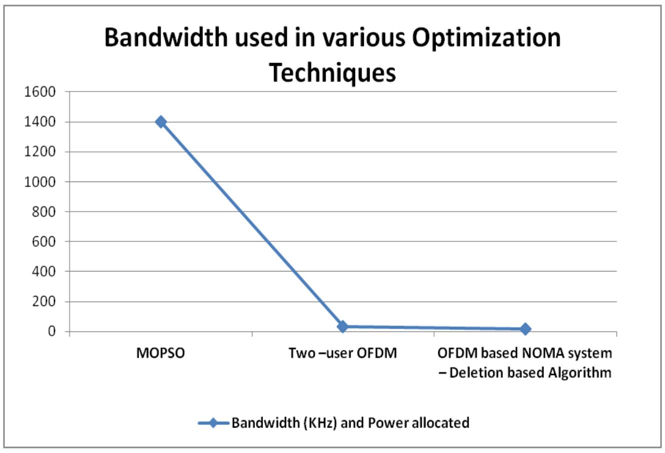

Fig- 3.1(b) Comparison of bandwidth used in various optimization techniques.

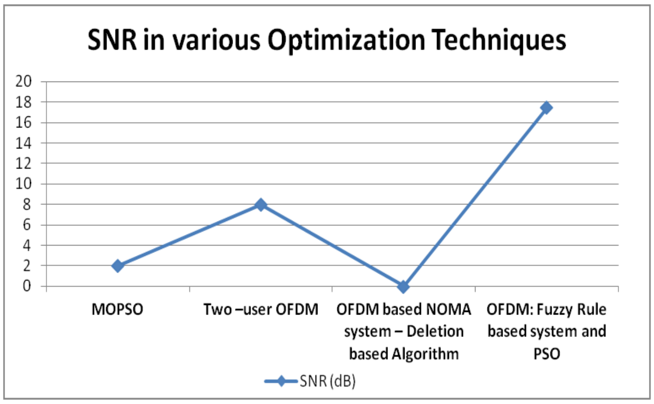

Fig- 3.1(c) Comparison of Signal to Noise Ratio used in various optimization techniques.

V. CONCLUSION

In this paper different surveys had made on optimization techniques for resource allocation in different wireless systems like Orthogonal frequency division multiplexing systems, Cognitive Radio Network, Heterogeneous network and Adaptive cognitive Radio network were studied. Also energy efficiency, spectrum efficiency and best effort services of wireless channels were analyzed.

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