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A Survey on Resource Allocation in OFDMA Using Convex Optimization

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Abstract - Orthogonal Frequency Division Multiple Access (OFDMA) is the promising technique for ever increasing demand of high data rate services. This paper proposes the Resource allocation issues for multiuser wireless transmissions, based on orthogonal frequency division multiple Access (OFDMA) and convex optimization techniques which are widely used in the design and analysis of variety of communications problems. By using convex optimization we convert the highly non convex resource allocation problem into a sequence of convex sub problems. The proposed system will be designed, to solve the subcarrier and power allocation problems for multiuser OFDMA system. The aim of proposed system is to maximize total throughput while maintaining rate proportionality among the users and minimizing the total transmit power under the condition that the QoS requirement of each user can be guaranteed.

Keywords - *Resource allocation, Convex Optimization, OFDMA, Subchannel Assignment and Scheduling.*

1. Introduction

Resource allocation is a key technique that can significantly improve the system performance under guaranteed QoS to users. In wireless communication systems, the need to reliably and simultaneously provide multiple users with high data rate communication links leads to challenging optimization problems. Orthogonal frequency division multiple access (OFDMA) emerged as a promising downlink technique. This is capable of providing high data rates services and QoS. OFDMA is an extension of orthogonal frequency division Multiplexing (OFDM). In OFDM systems, only a single user can transmit on all of the subcarriers at any given time. Time and frequency division multiple access (FDMA) techniques are used in OFDM to support multiple users. On the other hand, In OFDMA, multiple access is achieved by first dividing the spectrum of interest into a number of subcarriers, that are used to transmit data to multiple user and then assigning subsets of the subcarriers to individual users. The multiple user are served at a time hence resource allocation problem occurs in OFDMA systems. The basic diagram of a resource allocation in OFDMA can be illustrated in Fig. 1. As shown in fig. the base-station (BS) and each user are equipped with a single antenna. The BS has knowledge of each user channel state information (CSI), as the OFDMA assigning subcarrier to user on the basis of their channel gain. The BS allocates subcarrier, power and data rate to each user. To proportionally maximize the user data rates, subject to total power, bit error rate among user data rates.

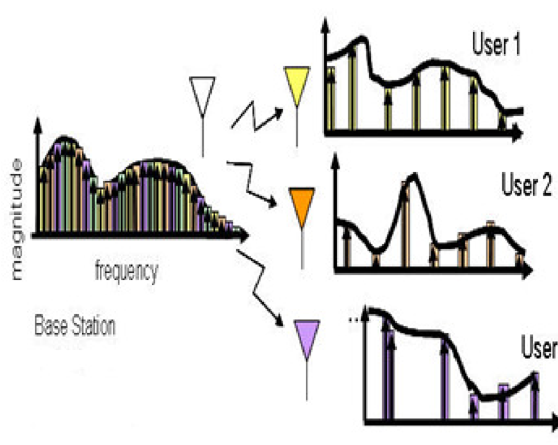

Fig 1. Resource allocation in OFDMA for K users

We shall formulate an optimization problem to maximize the system throughput. In terms of resource allocated to each user, the system throughput is not convex; this lack of a convex structure makes it impossible to obtain the optimal solution. Hence we convert the original non-convex problem into a sequence of convex problems, which can be solved by existing optimization algorithms.

In OFDMA, many problems are come while doing resource allocation such as, intracell interference (ICI) [1], fair resource allocation [2],[6],[10] in which joint sub channel and power allocation [4] problems is solved, imperfect channel state information (CSI) [3], maximize the ergodic rate capacity[9] and distributed scheduling [5], non convex optimization problem [7] in this problem is transformed into a convex optimization problem by time-sharing strategy. Increase capacity of a multiuser OFDM system [8].

The remaining paper is organized as follows: Section II present the previous work. Section III describes the proposed work. The expected outcome of the proposed system is discussed in Section IV. Lastly section V provides the conclusion.

2. Related Work

Yiwei Yu, Eryk Dutkiewicz, Xiaojing Huang and Markus Mueck [1], develop the sub channel and power allocation scheme to provide better system performance in multicell network. Author proposed the heuristic algorithms for sub channel allocation process. Lagrange dual method and geometric programming have proposed to solve optimization problem. Vu Nguyen Ha, and Long Bao Le [2], proposed problem related to fair resource allocation for OFDMA based femtocell network, with microcell protection. For this water filling algorithm and game theory technique are used.

Here an author proposes two methods: in first FUEs (femtocell user equipment) produce interference to MUEs (microcell user equipment). In second, auction based algorithm is used to optimize the channel assignment. Zheng Chang, Tapani Ristaniemi and Zhisheng Niu [3], jointly considered the relay selection and subcarrier allocation scheme. Hence fundamental properties are considered i.e. selection of relay, resource allocation for sub channel, power and CSI imperfection.

Here author does not consider the direct link from source to destination. In particular the two hops are considered, in first hope transmission duration of source to relay link and relay to destination link in second hope. Karthik and Neelesh B. Mehta [4], proposed the distributed and user pairing algorithm. Split select algorithm is come under distributed algorithm which is used to opportunistically assign the sub channel with limited feedback. Proposed algorithm based on channel gain i.e. the time slotted algorithm, used for every user maintenance of each sub channel. If success occurs, sub channel get assigned and the algorithm will be terminated.

The algorithm will be combined to provide benefit of filtering among user and sub channel. Ian C. Wong, and Brian L. Evans [5], investigate the resource allocation problem related to margin adaptively for minimizing the transmitted power, user data rates and bit error rate (BER). In this shows that the ergodic rate should be maximized by allocating the sub channel to each user, water filling algorithm should be considered for optimization.

Zhu Han, and K. J. Ray Liu [6], develop the game theory for resource allocation in OFDMA. using game theory the overall system performance should be maximized. In this Nash Barganing solution and coalition are considered. Barganing algorithm based on condition pair among user. It works into two ways: in first it considered two users and in second way it groups the user in group of size.

3. Proposed System

In this section, the system model for resource allocation in OFDMA is described. Proposed system is used to investigate the resource allocation problem for downlink OFDMA. The subcarrier and bit allocation problem are mathematically formulated. Consider an OFDMA downlink transmission system with k users and n subcarrier as shown in Fig.1.

In orthogonal frequency-division multiplexing (OFDM), the frequency band is split into multiple independent resource blocks that can be modeled as non-interfering flat narrowband channels. In OFDMA systems, multiple users are served simultaneously by assigning these subcarriers to users in such way that each subcarrier is occupied by at most one user. Modulation techniques and adaptive coding allow users to adapt their data transmission scheme to the wireless channel conditions on a per-subcarrier basis to maximizing frequency diversity gain.

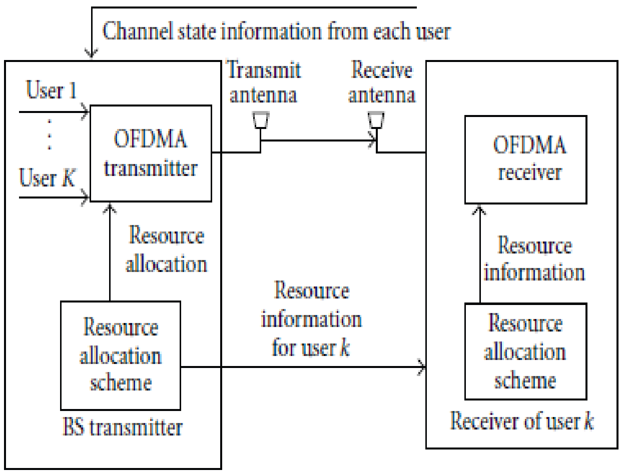

Fig 2. Block diagram of OFDMA for K user

Figure 2 shows the block diagram of OFDMA for k user. In the Base Station (BS), Channel State Information (CSI) from each user is sent to the resource allocation scheme block through the feedback channels. The resource allocation scheme is forwarded to the OFDMA transmitter. By selecting different number of bits from different users, the transmitter forms the transmitted OFDMA symbol. From each user, the channel information is collected as soon as the resource allocation scheme is updated and also the resource allocation information is sent to each user for detecting.

The resource allocation in OFDMA consists of multiple interdependent problems such as:

- Subcarrier assignment
- Choice of modulation levels
- Global and/or local power budgets
- Rate and fairness requirements

The working of each of the module is explained in detailed below.

3.1 Resource Allocation Schemes

This section consists of two parts. The first part introduces the resource allocation for single user. The second part evaluates resource allocation problems for multiuser in OFDMA.

3.1.1 Resource Allocation for Single User

Before try to solve allocation problem for multiuser, we first find out the allocation algorithm for single user environment. The single user problem not only provide better understanding of the issues involved in single user but also gives a bit allocation algorithm. That we can use in multiuser resource allocation solution. In single user case, we assign one bit at time to the subcarriers. In the sense of minimizing the overall transmit power that requires additional power gives an optimal allocation.

3.1.2 Resource Allocation or Multiuser

In multicarrier systems, the total transmit power is minimized which is equivalent to minimizing the power required on each subcarrier. A subcarrier can be occupied by at most one user; to avoid severe co-channel interference (CCI). So, the system can be viewed as a single user system on each subcarrier.

3.2 Non convex Optimization Problem

In this we introduce some conditions under which non-convex optimization problems is converted into convex function for multi-user systems. The convexity property makes optimization easier. The convex optimization problem requires the objective function f to be minimized and the feasible set is convex. The convex optimization problem is solved by using Lagrange dual method and geometric programming.

In linear programming (LP) case, the objective function are both convex and concave, hence LP can also consider the problem of maximizing an objective function. The objective function is not concave, in most convex minimization problem. Therefore such problems are formulated as the standard form of convex optimization problems, so it is very necessary to minimize the convex objective function.

The optimization problem having following general form:
$x^* \in X$ such that
$f(x^*) = \min\{f(x) : x \in X\}$,
Where $x \subset \mathrm{R}^n$ is the feasible set and
$f(x)$: $\mathrm{R}^n \rightarrow \mathrm{R}$ is the objective,

Is called convex if X is a closed convex set $f(x)$ is convex on R^n.

3.3 Subcarriers Allocation and Power Allocation

In this to solve optimization problem, the subcarriers and power should be allocated jointly. The computational complexity is prohibiting by using this process. The subcarrier and bit allocation problem are mathematically formulated. Table 1 shows the notation used for mathematical formulation.

Table 1: Shows the notation used for mathematical formulation

Symbol	*Description*	*Value/Range*
K	Number of user	16
N	Number of sub carriers	64
K	Index of user	$1 \leq k \leq K$
N	Index of subcarrier	$1 \leq n \leq N$
$P_{k,n}$	Power assigned to per subcarrier per user	
B	Bandwidth	1MHz
N_o	Noise power spectral density	
$H_{k,n}$	Subcarrier signal to power ratio	$g_{k,n}^2/ \ ^2$
R_k	Total data rate for k user	
P_{tot}	Total power available	1W
$\varnothing$	Proportionality Constant	

4. Proposed Solution

The proposed system able to provide two outcomes, which are as follows:

1. Minimize the total transmitted power under the condition that each user has guaranteed Quality of Service (QoS).

2. By reducing the computational complexity, significantly achieves improvement in overall system performance.

5. Conclusion

In the proposed OFDMA system, optimal resource allocation is performed independentally for each user to maximize the system performance in terms of throughput and introduced the convex optimization tool for solving computational complexity.

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