Efficient Resource Allocation and Adaptive Scheduling to Enhance MIMO-OFDMA System Parameters

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***Abstract*— The combination of multiple antennas and multi-carrier technology has the potential to largely increase the capacity of wireless communications and represents an air-interface solution for the next generation systems..Even though the multicarrier systems reduces Inter Symbol Interference (ISI), the Orthogonal Frequency Division Multiple Access (OFDMA) multiple input multiple output (MIMO) systems have the problem of adaptive scheduling. The systems suffer Multiple Access Interference (MAI) at receiver spatial filters and hinder the performance of the sequential allocation.The method to reduce the effect of MAI and thereby increasing the system performance is the efficient resource allocation of the signals to each sub channel .So a novel heuristic strategy that partitions the users in different groups based on their average channel quality and addresses the problems by a lower-complexity allocation is implemented. The linear programming approach is combined with water-filling strategy will ease the task of resource allocation. The system efficiency is achieved by the efficient subcarrier, power, bandwidth allocation, the linear transmit and receive filters and BER (Bit Error Rate) reduction of the signals using link gain based grouping. The work also comprises of a comparative study of the system efficiencies.**

***Keywords*— Scheduling,MIMO, OFDMA, Channel Assignment ,ISI,MAI.**

I. INTRODUCTION

Wireless spectrum is a valuable resource and propagation conditions are hostile due to fading and interference from other users hence we need to increase spectral efficiency and improve link reliability. Multiple Access wireless technology seems to meet these by offering increased spectral efficiency through spatial multiplexing gain, and improved link reliability due to antenna diversity gain.

Multiple Access Interference (MAI) and the Bit Error Rate (BER) should be considered in order to increase the spectral efficiency. This is done by the Linear Programming Sequential Channel Assignment Algorithm (LPSCA).Orthogonal Frequency Division Multiple Access (OFDMA) is a multi- user version of the popular Orthogonal Frequency Division Multiplexing (OFDM)digital modulation scheme. Multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual users. This allows simultaneous low data rate transmissions.

Resource allocation in MIMO-OFDMA systems has the potential for achieving large diversity gains but is extremely complex and computationally demanding since it requires the joint assignment of a) linear transmit and receive spatial filters b)channel assignment and c) power allocation d) bandwidth utilization over all the parallel links. Moreover, due to channel assignment and the presence of MAI, the allocation problem is not convex. The objective of resource allocation is to maximize the system throughput or minimize the overall transmit power, while satisfying some constraints, such as bit error rate (BER) and minimum data rate. In order to achieve the objective, resource allocation in the OFDMA system has three basic tasks: subcarrier allocation, bit allocation, and power allocation. The well-known optimal power allocation in maximizing the system capacity under a total power constraint is water-filling principle, which instructs that more power is allocated to the sub channel with better channel condition. When allocating subcarriers to different users, the multiuser diversity is an important concept to allow users to properly share sub channels according to the instantaneous channel conditions of the users. In a downlink OFDMA system, when sub channels are mutually independent from user to user, and that the best performance, such as the maximum bits per symbol or the minimum transmit power, can be achieved by allocating single subcarrier to the user with the best channel condition over the corresponding sub channel, and allocating the transmit power over all sub channels in terms of the water-filling principle.

II. RELATED WORK

Joint chunk, power and bit allocation has been explained in [8] by Zhu.H. et.al. In this the channel is assigned to different users on the base of the link gains. The resource allocation is done on chunk based model where multi level transfer is enabled. Scaling factor is considered for the optimal allocation and is based on a dynamic power allocation method. Although the maximum throughput or the minimal transmit power can be achieved by the subcarrier-based allocation scheme wireless transmission to convey channel and modulation information for each subcarrier, and is complicated.

Optimal spectrum balancing algorithm has been implemented in [7] by Wei Yu.et.al. This paper is based on the transmissions based on the time sharing condition for the multiuser spectrum optimization This is an effective approach when the number of frequency carriers goes to infinity.This paper makes progress toward numerical solution of non convex optimization problems for multicarrier systems by studying their fundamental properties. In particular,paper focus on the characterization of the Lagrangian dual of these non convex problems.

III. PROBLEM STATEMENT

The downlink of a MIMO OFDMA system is considered. By properly dimensioning the OFDM parameters, the signal bandwidth is divided in N frequency-flat orthogonal channels, which are assigned to the K users in the system. The base station (BS) is equipped with NT antennas and each of the K different users is equipped with NR antennas. Moreover, we assume a quasi-static scenario, in which channel gains are approximately constant between consecutive allocations ,so that the presence of either a feedback link or channel reciprocity allows both the BS and the mobile users to possess full knowledge of channel state information (CSI).Assuming that NT>NR and that at most Q = NT/NR users are allocated on each subcarrier, let us focus on sub channel n and suppose that the set U collects the users $U_{n,1}$,...,$U_{n,q}$, which are simultaneously assigned on channel n. The transmitted signal of user K on subcarrier n will be,

$$X^{N}_{n,k}\sum_{l=1}^{ln,k} b_{n,k}S_{n,k} \qquad (1)$$

Where, $b_{n,k}$ is the unit-norm linear precoder.

$s_{n,k}$ is the actual informative symbol transmitted.

The signal received will be,

$$Y_{n,k} = H_{n,k}x_{n,k} + i_{n,k} \qquad (2)$$

Where,$H_{n,k}$ is the channel Matrix $i_{n,k}$ is the Multiple Access Interference(MAI) generated.

Multiple access interference will affect the system performance which will occur mainly when power of the signal transmitted will be greater than the desired signal.

$$i_{n,k} = H_{n,k}\sum_{j\neq k, j\in un} x_{n,j} + n_{n,k} \qquad (3)$$

Where, $n_{n,k}$ is the additive white Gaussian noise generated.

At the mobile receiver K ,the data stream on sub channel n is recovered by linearly filtering the output of the N_R antennas which will be considered as,

$$Z_{n,k} = W_{n,k}y_{n,k} \qquad (4)$$

$W_{n,k}$ is the linearly filtered output.

Assuming that the total number of users is, K$\leq QN$ the MA multiuser multi-carrier resource allocation problem, defined over the vectors x and a that collect all the transmitted signals and the allocation variables, can be formulated as,

$$min_{x,a}\ \sum_{n=1}^{N}\sum_{K\in}^{N}\mu_r tr(R_{xn,k}) \qquad (5)$$

Subject to,

$$\sum_{n=1}^{N} a_{n,k}r_{n,k}(x,a)\geq R_k$$

$$|u_n|\geq Q$$

$$1\leq n\leq N$$

Where, set of constraints accounts for user's rate requirements and $r_{n,k}$ is the rate of user n on link k and the other constraints indicates that no more than Q users are allowed per sub channel. The above is called as qth resource allocation problem that should be solved.

IV.PROPOSED METHOD

The existing Linear Programming Power Allocation (LPPA) is subjected to further more improvement in case of considerable reduction in MAI and hence by increasing the spectral efficiency of the system . The spatial transmit filters of users in A_q cannot be modified to avoid compromising, the optimality of the existing allocations. This implies that the transmissions of users in K will be necessarily be affected by the interference generated by the users in A(q).Thus the received signal on channel n for user k $\in kq$ *is*

$$y_{n,k} = H^{q}_{n,k}B_{n,k}s_{n,k} + i_{n,k} \qquad (6)$$

Where, $i_{n,k}$ is the MAI,$s_{n,k}$ is the actual informative signal transmitted.In the large majority of the cases, by giving higher priority to the subsets of users with lowest channel quality, the algorithm is able to make the most of the existing system diversity.

a)Sequential Channel Assignment(SCA)

Assuming that up to Q users can be allocated on a given subchannel, the successive channel assignment algorithm (SCAA) splits the original problem in Q different problems and solves them sequentially. By construction, each of the Q problem would be defined for a subset of only K/Q users and the amount of computations required for solving each problem isa fraction of the complexity of the original problem. In details, SCAA can be summarized in two steps,

1) Partition the K users in Q orthogonal sets K_1,…..,K_Q on the base of a certain metric.
2) Solve Q successive resource allocation problems on the setsK_1,…..K_Q starting from the users in K and terminating with the users in K_Q.

b) User Partitioning

Finding the optimal partition of K users in Q groups requires an exhaustive search over all the possible users' combinations. The users are divided in groups K_1,…..,K_Q with the goal of exploiting the diversity of the system and optimizing the performance .In this there are k=12 and Q=3. The users that have the worst channels consume the most power and, hence their channel assignment is critical for the overall system power consumption. There fore, the criterion we adopt is that users most distant from the BS are allocated first(most distant first, MDF). As a measure of the link quality for user k, the average value of the traces of the channel matrix

$$,\ d_k = {}^{1}/_{N}\sum_{n=1}^{N} tr(H^{H}_{n,k}H_{n,k}) \qquad (7)$$

(3.5)

Where, N is the number of users, $H_{n,k}$ is the channel matrix. When considering link quality of the users, the user that may come first will be with less power than that come last with more power . Priority will be given to signal with less link quality and hence the loss of signals can be avoided (3.5.1)

c) Resource Allocation on Water Filling Strategy (3.5.2)

Water filling strategy will ease the allocation of the system requirements especially in terms of power. This holds good to schedule which transmitter should send the signal in minimum power. Allocations will be done so as to avoid the effect of cross talk. In this method water filling strategy will provide the cost required for the sub channels in terms of power. The total transmit power is minimized and they are done subjected to the conditions that this rate should me made equal to the power of the channel considered

d) Linear Programming Algorithm and Power Allocation (LPSCA):

In a multi-carrier system, margin adaptive (MA) channel assignment is designed to allocate to each user the best possible subset of available channels with the goal of minimizing the overall transmitted power subject to the individual rate constraints R_k(k =1,...,K).Let $a_{n,k}$be a binary allocation variable that is equal to one if sub channel n is assigned to user k and zero otherwise so that the set collecting all the users k assigned on sub channel n is u_n.Assuming that the total number of users is K≤QN, the MA multiuser multi-carrier resource allocation problem, defined over the vectors x and a that collect all the transmitted signals and the allocation variables, can be formulated as

$$min_{x,a} \sum_{n=1}^{N} \sum_{K \in U_n} tr(R_x, k) \quad (8)$$

Subject $to\, u_n < Q \quad 1 \le n \le N$

$$\sum_{n=1}^{N} a_{n,k}\, r_{n,k}(x,a) \ge R_K \quad (9)$$
$$1 \le n \le N$$

where the set of constraints (3.8.2) accounts for the users' rate requirements and r is the rate of user n on link k and the set of constraints(3.8.1) dictates that no more than Q users are allowed per sub channel .Unfortunately, due to the interference and the presence of, problem is not convex and its solution implies an exhaustive search to come up with optimal channel assignment, optimal transmit and receive spatial filters and optimal power allocation and bandwidth allocation, so that even in the simplest scenarios its computational complexity is too high to be practically feasible.

To further simplify the allocation task, we follow the linear programming (LP) approach discussed in by assuming that each user transmits with a given rate ρ_k on all assigned sub channels, the requirement on the user rate $R_k$translates into requesting a certain number of sub channels per user. By doing so in this case the power is not an optimization variable but simply the cost of using a certain resource and the best assignment is the one that meets the requirements minimizing the sum of the costs. The cost $P_{n,k} = \sum_{l=1}^{l_{n,k}} p_{n,k}$of using the sub channel n for user k in $k_q$is the minimum amount of power required to transmit the rate ρ_k on the parallel streams associated to the non-zero singular values of R and is formulated as the water filling problem with a rate constraint,

$$min_p \sum_{l=1}^{l_{n,k}} p_{n,k} \quad (10)$$

Subject to

$$\sum_{l=1}^{l_{n,k}} log_2\left(1 + p_{n,k} h_{n,k}\right) = p_k \quad (11)$$

Whose solution is the water filling power distribution

$$p_{n,k} = (\mu_{n,k/log\,2} - \frac{1}{h_{n,k}}) \quad (12)$$

where the value of μ is chosen to meet the rate requirement. In this setting, the q-th resource allocation problem(3.5) translates to the channel assignment problem for users in set k_q.

$$min_a \sum_{n=1}^{N} \sum_{k \in kq}^{N} a_{n,k}\, p_{n,k} \quad (13)$$

Subject to $\sum_{n=1}^{N} a_{n,k} = n_k \quad k \in kq$ (14)

$$\sum_{k \in Kq}^{N} a_{n,k} \le 1 \qquad n = 1, \dots \dots N \quad (15)$$

Where, $a_{n,k}$ is the binary allocation variable

n_k is the number of sub channels

$p_{n,k}$ is the power allocated for a channel

The assignment is performed only on the K/Q users in k_q

Constraints (14) account for the users' rate requirements. Moreover, it can be easily solved by efficient algorithms that run in strong polynomial time. After having solved the channel assignment problem (3.10), power consumption can be further reduced by removing the condition that each user has to transmit with a fixed throughput ρ_K on all the assigned channels. Having defined $S_k = \frac{n}{a_{n,k}} = 1$ as the set of subcarriers assigned to user k, for each user k power usage is minimized by solving

$$min_p \sum_{n \in s_k} \sum_{l=1}^{l_{n,k}} p_{n,k} \quad (16)$$

Subject to

$$\sum_{n \in s_k}^{N} \sum_{l=1}^{l_{n,k}} log_2(1 + h_{n,k}\, p_{n,k}) = R_k \quad (17)$$

The solution again is the wateling olution so that it is,

$$p_{n,k=}\left(u_{\frac{k}{log\,2}} - \frac{1}{h_{n,k}} \right), l = 1, \dots \dots . l_{n,k;}$$

$$n = 1, \dots . N \quad (18)$$

And the Lagrange multiplier μ is set so th*at*

$$\sum_{l=1}^{l_{n,k}} log_2\left(1 + h_{n,k} p_{n,k}\right) = R_k \quad (19)$$

In the following we will indicate as LP-based SCA (LPSCA) the proposed resource allocation strategy.The allocation based on bandwidth will be considered and provide an accurate estimation of the amount of information transmitted.

Each channel bandwidth is calculated. Spectral efficiency represents the capacity of a system. Bandwidth efficiency represents the information rate that can be transmitted over a given bandwidth in a specific communication system

Spectral Efficiency=Maximumthroughput/Bandwidth of channel.

R=$\sum_{K}^{N} R_K = W \propto$ (20)

Where, ∝ is the target spectral efficiency.

IV. EXPERIMENTAL RESULTS

The proposed system is designed to produce improved spectral efficiency. The effective resource allocation represents a solution for MAI and the performance improvement.The output is being achieved using MATLAB Version 7.10 R2012a.

We consider that the users are uniformly distributed in a cell of radius R=500m.The bandwidth in total is considered as W=5MHz which is distributed with the uniform allocation is the maximum bandwidth allotted for a sub channel.Datas satisfying the conditions of bandwidth and power will be assigned the sub channel according to the link quality of the signal. The input is random data generation which is allocated to 12 users that are considered in the system.

The path loss component $\gamma = 4$. The system we considers is with four transmitting and two receiving antennas. The propagation channels are independent from antenna to antenna. The rate is fixed for all users.

System considers the calculations as follows, it will assume a fixed data rate for all the transmissions and all the parameters are optimized based on to meet the rate requirement of the channel. Depending on the SNR we send in transmission for experimental calculation random data will affected by the fading and the MAI and hence increases the BER.Power distribution of users are considerably more effective in link gain based allocation. Bandwidth is allocated based on power allocated per sub channel. This will upgrade the system performance with 2% more efficiency.The proposed system outperforms the existing one through an increase in the BER reduction and the spectral efficiency with an appropriate user grouping algorithm and linear programming.

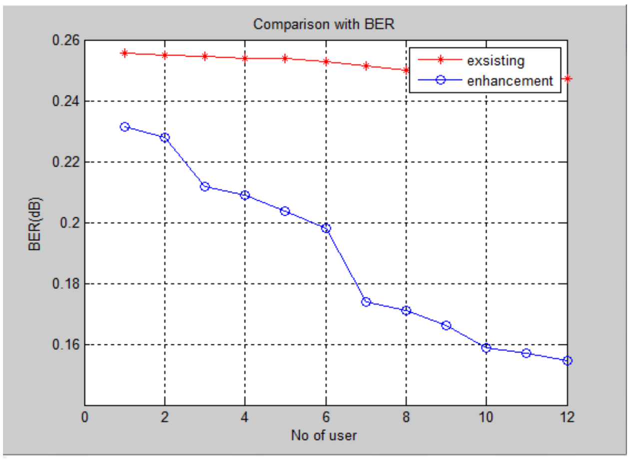

Fig 4.8.BER comparison of two systems
The BER of the proposed system has decreased considerably and the communication quality is maintained.

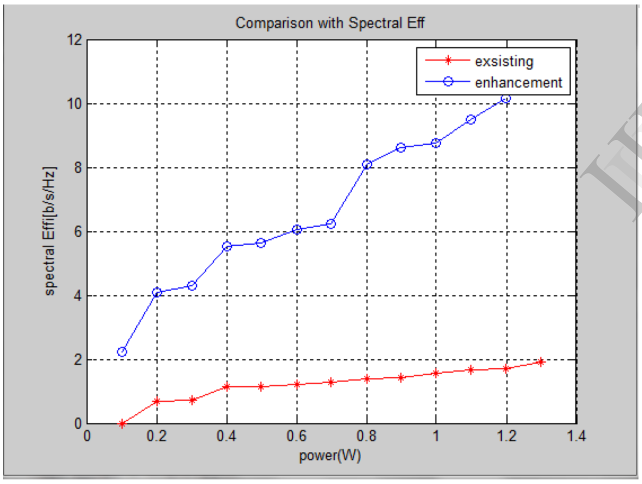

Fig 4.9. Spectral efficiency with power
Spectral efficiency is doubled when link gain based allocation is done. This shows that grouping strategies determine the system

performance.LPPA BER=0.255 dB ,LPSCA BER=0. 141dB. This BER and spectral efficiency is achieved when the users are partitioned on the link gain basis.LPPA Spectral efficiency=1.6 b/s/Hz ,LPSCA Spectral efficiency=4.8 b/s/Hz

V. CONCLUSION

The performance of a MIMO-OFDMA system with effective resource allocation scheme is analyzed. The efficiency is achieved by allocating the data to the appropriate sub channel that can hold specific power and bandwidth required for transmission. The MAI is reduced when resources are allocated suitably since the new users will not be interfered by the users already allocated. The spectral efficiency can be increased more with increased power that is analyzed in system implementation. Grouping based on link quality is found as an effective partitioning strategy which considers users more distance from base station first with no matter of how much data level it carries. Maximum data preservation can be achieved even though other interferences affect the system.Complexity of the algorithm is a factor that reduces the effect of suggested mode of allocation. An algorithm can be implemented with less complexity for resource allocation. Furthermore error rate can be dealt by reducing the Inter Carrier Interference (ICI) of the MIMO-OFDMA systems.

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