MARGIN ADAPTIVE POWER ALLOCATION USING CHANNEL STATE INFORMATION IN OFDMA SYSTEMS

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Abstract

The paper presents the margin adaptive resource allocation using full CSIT (Channel State Information) and statistical CSIT in OFDMA systems. In the past, Monte-Carlo snap-shots in the MA problem is far too complex, an analytical expression of the outage capacity as a function of the Signal-to-Noise Ratio (SNR) and of the outage probability is more complexity. In the paper is used full CSIT and statistical CSIT to obtained for the outage capacity, as a function of the SNR and the outage probability. The proposed methods avoid power divergence situations at any load, and are consequently more efficient than iterative water-filling to solve the MA problem.

Index Terms—*Distributed resource allocation, margin adaptive problem, MIMO, OFDMA, inter-cell interference.*

I. INTRODUCTION

orthogonal frequency division with multiple access (OFDMA), is based on OFDM and provides an orthogonal multiple access method. OFDMA allows multiple users to share an OFDM symbol, each owning a mutually disjoint set of subcarriers. Since the different users experience mutually uncorrelated fading, it is possible to obtain multiuser diversity gains by exploiting a channel aware resource allocation scheme which improves the total offered capacity.

Two types of multiuser resource allocation problems are referred as margin adaptive (MA) [3] and rate adaptive (RA) [4, 5, 6, 7]. The margin adaptive objective is to minimize the total transmit power with subject to constraints on the users' data rate and bit error rate (BER). The rate adaptive aims to maximize the overall system capacity with a total power constraint. Wong et al [1,2,7] extended the rate maximization problem to deal with the proportionality constraint by introducing a predetermined set of priority parameters.

The proportionality constraint is an important condition which allows for quality of service (QOS) level differentiation and flexible billing mechanism. The algorithm proposed in [7] is a near optimal solution, but requires solving a set of nonlinear equations for power distribution and hence, is complex. In [1], the previous solution has been simplified by assuming that each user should be assigned a number of subcarriers proportional to its predefined priority index. This assumption results in linear equations for power distribution among users, and hence a large simplification is obtained. On the other hand, however, the recent algorithm does not guarantee a tight fulfillment of proportionality.

II. MIMO IN FULL CSIT

The algorithm of power control in FULL CSIT is shown below

Initilization:Nt=0 Pbk=0
For *Nt=1 to $N_{t,max}$*
For *k=1 to KN do*
For *L ε θk do*
Update TK depending upon P_{bk} from iteration N_t-1
Update Qk depending upon P_{bk} and Qk from iteration N_t-1
Compute singular values i.e
β1,β2…..β_{nmin} is the ordered eigen values of $(H_{bk})^H H$
end **for**
while *Rk # Rk,target do*
for *j=1 to ήmin do*
compute $\rho_k d_{k,j}$
end **for**
compute R^l_k

$$\text{If } E^l_k \tau^l_k \geq \delta \text{ and } R^l_k > R^l_{k,\max} - \epsilon, \text{ set } R^l_{k,\max} - \epsilon$$

End **for**
Compute $R_k = \sum R_k$
End **while**
For *L ε θk do*
If *$R_k = R_k$, max –ε*
While *$R_k = R_k$, max –ε*
for *j=1 to ήmin do*
compute $\rho_k d_{k,j}$
end **for**
compute R^l_k

$$\text{If } E^l_k \tau^l_k \geq \delta \text{ and } R^l_k > R^l_{k,\max} - \epsilon, \text{ set } R^l_{k,\max} - \epsilon$$

End **for**
Compute $R_k = \sum R_k$
End **while**
End **for**
End **for**

The convergence criterion for full CSIT MIMO cannot theoretically guarantee that there will not be any power divergence situation with this criterion. However, the numerical results show that full CSIT is quite efficient compared to iterate water-filling, both at low and high load. At low load, the convergence criterion is not too restrictive. Whereas at high load, it identifies the subcarriers with potential power divergences and efficiently limits the allowed power level on these subcarriers.

We first focus on subcarrier *l*.Let Ωi be the set of interfering users in subcarrier *l*, with |Ωi| ≤ N. The received vector for user K served by BS is given by

$$y^l_k = \sqrt{\rho^l_k}\mathrm{H}^l_{b_k,k}\mathrm{x}^l_k + \sum_{\{n\in\Omega_l, n\neq k\}} \sqrt{\mu^l_{b_n,k}}\mathrm{H}^l_{b_n,k}\mathrm{x}^l_n + \mathrm{n}^l$$

Where

$X_n{}^1$ is the vector transmitted by the base station b_n to user *n*

$H^l b_{n,k}$ is the vector transmitted by the base station b_n to user *n*

n_l addadive white Gaussian noise vator

$g_{bn.k}$ is the channel gain between BS bn and user n, including path loss and shadowing

$\rho_k,^1 = g_{bn.k} P_b/No$ is the SNR of user k

When using a Minimum Mean Square Error (MMSE) receiver, defined as

$$\mathrm{W}^l_k = \frac{(\mathrm{Q}^l_k)^{-1}\mathrm{H}^l_{b_k,k}\mathrm{V}^l_{b_k}}{\left\|(\mathrm{Q}^l_k)^{-1}\mathrm{H}^l_{b_k,k}\mathrm{V}^l_{b_k}\right\|_F}$$

The Singular Value Decomposition (SVD) of FULL CSIT is

$$(\mathrm{Q}^l_k)^{-1/2}\mathrm{H}^l_{b_k,k} = \mathrm{U}^l_{k,1}\Lambda^l_k(\mathrm{U}^l_{k,2})^H$$

Where

U is the unitary matrix

Л=diag(λ1,λ2…..λ_{nmin}) is diagonal with real non-negative elements. Using the SVD, we obtain that the mutual information is maximized.

III. STATISTICAL CSI

The STATISTICAL CSIT avoids the outage capacity and FULL CSIT minimizes the power diversity situations that lead to many users being rejected by admission control. In statistical CSIT the outage capacity as a function of the SNR and of the outage probability has been determine as shown below

$$C_{\min} = \log_2\left(1 + \frac{f(P_{\text{out}})}{n_t}\rho\right)$$

Where

$$f(P_{\text{out}}) = f(\zeta^{n_r n_t})$$
$$= 2\sqrt[4]{\frac{3}{2}}\zeta + \frac{2\sqrt{6}\zeta^2}{5} + \frac{34\zeta^3}{252^{3/4}\sqrt[4]{3}} + \frac{388\zeta^4}{875}$$

The arithmetic mean of the upper and lower bounds is a concave function of the SNR, defined as

$$\tilde{C} = \frac{1}{2}\left(n_{\min}\log_2\left(1 + \frac{f(P_{\text{out}})}{n_{\min}n_t}\rho\right) + \log_2\left(1 + \frac{f(P_{\text{out}})}{n_t}\rho\right)\right)$$

The performances in the statistical CSIT case, because only 55% of the subcarriers are required to reach the target data rate of all users. Thus, compared to iterative water-filling, the inter-cell interference decrease counterbalances the fact that orthogonalization allows only 33% of the subcarriers to be used for transmission. However, the average inter-cell interference per active subcarrier is of the same order with users orthogonalization as with our proposed method, which explains why our proposed method performs better.

IV. RESULTS

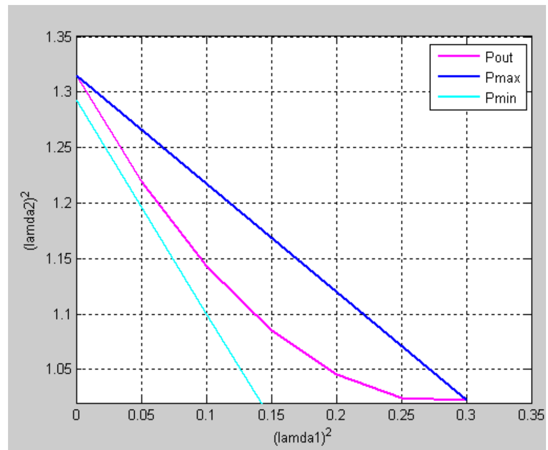

Fig. 1. n_{min} =2, bounds on the outage probability.

The blue curve is $2c=(1+\Gamma/n\lambda_1^2)\ (1+\Gamma/n\lambda_2^2)$ and the blue area is Pout . The green curve is obtained with the arithmetic-geometric means inequality $2c= 2+\Gamma/n\lambda_1^2+\Gamma/n\lambda_2^2$. The red area is the upper bound, Pout, max.

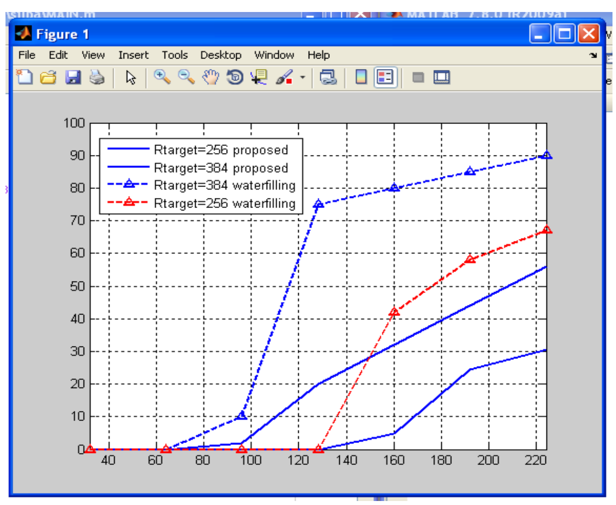

Fig. 2. Full CSIT, percentage of rejected users depending on the load

The iterative water-filling leads to an abrupt increase of the percentage of rejected users, whereas our proposed method avoids this behavior

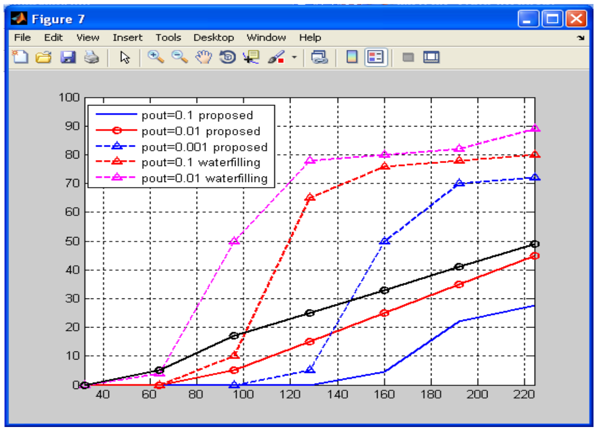

Fig. 3. Statistical CSIT, percentage of rejected users depending on the load and on Pout.

The statistical CSIT is more efficient in terms of rejection rate than iterative water-filling, whatever the outage probability value.

V. CONCLUSION

In this paper, full CSIT and statistical CSIT can avoid Margin Adaptive problem in MIMO OFDMA . A convergence criterion has been derived in both cases, and included within subcarrier allocation and iterative power control. In both cases, the proposed method avoids power divergence situations, compared to iterative water-filling, and leads to more users reaching their target data rate. Future work will extend these results to the interference channel, where interference is no longer considered as noise. Resource allocation will then be optimized jointly with interference alignment or superposition coding.

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