International Journal of Current Engineering and Technology
E-ISSN 2277 – 4106, P-ISSN 2347 - 5161

Available at http://inpressco.com/category/ijcet

Research Article

Resource Allocation Scheme in Mimo OFDMA Based Wireless Network using GS Precoder

R.Prabakar[Ȧ*] and Krithiga.S[Ȧ]

[Ȧ]Department of ECE SRM University Kattankulathur, Tamil Nadu,Chennai-603203.

Accepted 20 March 2014, Available online 01 April 2014, **Vol.4, No.2 (April 2014)**

Abstract

The Orthogonal Frequency Division Multiple Access (OFDMA) when used in wireless networks provides high spectral efficiency with robust performance and thus been considered for 4G air interface technology. On the other hand, the MIMO technique that uses multiple antennas at the base station and the mobile station provides spatial diversity and multiplexing gain. Adaptive Resource Allocation technique has been considered for maximizing the capacity taking QoS requirements. A precoding scheme named Gram-Schmidt (GS) precoder is proposed which follows the conventional approach invoking the Singular Value Decomposition (SVD) to obtain the pre-processing and the post-processing vectors for different users through proper linear combinations of the singular vectors. In this project, two algorithms space/frequency allocation algorithm and constraint-relaxation based greedy search algorithm are to be used. These algorithms adaptively assign the subcarrier/power and select both pre-processing and post-processing vectors. This work design will be useful in minimizing the total transmit power and meet each user's QoS requirement.

Keywords: *GS (Gram-Schmidt) SVD (Singular Value Decomposition) QoS (Quality of Service)*

1. Introduction

The Orthogonal Frequency-Division Multiple Access (OFDMA) is a multi-user version of the popular Orthogonal Fequency-Division Multiplexing (OFDM) digital modulation scheme. Multiple access is achieved in OFDMA by assigning subsets of subcarriers to individual users as shown in the illustration below. This allows simultaneous low data rate transmission from several users(Chih-Lun Weng *et al*, 2010).

Assigns disjoint subsets of subcarriers to different users. When used for wireless MA, it provides high spectral efficiency with robust performance and thus has been considered or adopted as a candidate 4G air interface technology. It not only provides spatial diversity and multiplexing gain but also makes possible Space-Division Multiple Access (SDMA)(X. Lu Z. li *et al*, 2009).

On the other hand, the Multiple-Input Multiple-Output (MIMO) technique that uses multiple antennas at the Base Station (BS) and Mobile Stations (MS) as well has promised significant system capacity increase with respect to single antenna systems.

In radio resource management for wireless and cellular network, channel allocation schemes are required to allocate bandwidth and communication channels to base stations, access points and terminal equipment (M. S. Maw, 2007). The objective is to achieve maximum system spectral efficiency in bit/s/Hz by means of frequency reuse, but still assure a certain grade of service by avoiding co-channel interference and adjacent channel interference among nearby cells or networks that share the bandwidth(S. Pietrzyk *et al*, 2004).

Adaptive RA methods for maximizing the capacity or throughput have been proposed. Taking users' Quality of Service (QoS) requirements into account, proposed adaptive RA algorithms minimize the total transmit power(G. Liu *et al*,2008; M. Ergen *et al*, 2008).

The Singular Value Decomposition (SVD) is a factorization of a real or complex matrix, with many useful applications in signal processing and statistics. In order that multiple user signals over the same subcarrier can be perfectly decoupled at the receiver, we propose a precoding scheme named Gram-Schmidt (GS) precoder which follows the conventional approach invoking the Singular Value Decomposition (SVD) to obtain the pre-processing and the post-processing vectors for different users through proper linear combinations of the singular vectors(Z. Hu *et al*, 2006; Y. H. Pan *et al*, 2005).

Based on the above concept, we propose two algorithms that adaptively assign subcarrier/power and select both pre-processing and post-processing vectors(Q. H. Spencer *et al*, 2003). They are designed to minimize the total transmit power and meet each user's QoS requirement. The rest of this paper is organized as follows. Section II describes the channel model of the MIMO-OFDMA system as well as the structure of the GS precoder. In Section III, the resource optimization problem is formulated and two simple suboptimal solutions are presented(M. Ergen *et al*, 2008).

*Corresponding author: **R.Prabakar**

2. System Overview

We consider a system model for the downlink channel with n_T transmit antennas and K users, each equipped with $n_K{}^R$ receive antennas. We also assume an N-subcarrier OFDM modulation scheme and assume that each subcarrier experiences flat fading. This models a typical cellular downlink transmission scenario. With the assumption that both transmit and receiver beamforming are performed, the demodulated signal for user k on subcarrier n is

$$\hat{d}_{k=} D_{k,n}(H_{k,n}\sum_{i=1}^{k} M_{l,n}d_{l,n}+n_{k,n}) \quad (1)$$

where $d_{k,n}$ is the data vector for user k on subcarrier n, $H_{K,n}$ is the channel matrix,$M_{l,n}$ is the transmit beamformer matrix, $d_{l,n}$ is the receive beamformer matrix, and $n_{k,n}$ is a complex white Gaussian noise vector.

The general MIMO-OFDMA resource allocation problem consists of determining which subcarriers are assigned to each user (in the MIMO case, several users will share each subcarrier), how much power is transmitted to each user on each subcarrier, and what transmit beamformers will be used. Solving this general problem in an optimal way is often intractable, except for very simple scenarios. In this paper, to simplify the solution, we use the Block Diagonalization (BD) method to calculate the transmit beamformers, a technique which cancels out the inter-user interference at the transmit side. The resulting rate for user k under BD in a MIMO OFDMA setting will be

$$R_k=\sum_{n=1}^{K} \log_2|I+1/N_0\sum_{k,n}^{2} \Lambda_{k,n}| \quad (2)$$

where N_0 is the noise power, $\sum^2{}_{k,n}$ is the diagonal matrix containing the singular values of user K's channel on subcarrier n, and $A_{k,n}$ is the diagonal matrix with the power loading factors.

Even with the simplifications inherited from block diagonalization, directly constructing a resource allocation bargaining problem from (2) leads to a nonlinear integer programming problem, which is difficult to solve. Hence we apply some relaxations to the original model and turn it into a convex programming problem. Note that, with K users, there are a total of 2^k different user combinations that can be assigned to a given subcarrier n. Some of these combinations will not be feasible for BD, since the sum of the number of receive antennas for users on a given subcarrier cannot exceed n_T .

The transmit channels have weaker eigenmodes to "fit" the users with stronger eigenmodes by transmitting over an eigenchannel which lies within the dual space of the space spanned by all previously selected eigenchannels. Each new eigenchannel is obtained by using proper processing vectors which are linear combinations of known eigenvectors. The process is similar to a Gram-Schmidt orthonormalization process except that it follows a fixed descending eigen-magnitude order. Hence, a precoder based on the above design procedure is referred to as a Gram-Schmidt (GS) precoder.

3. Problem Formulation and Adaptive Solutions

A resource allocation algorithm to assign the sub carriers, power and load bits to each user such that the total transmit power of the system is minimized while the QoS of each user is satisfied. Let Rk denote the rate requirement for user k (bits/per OFDM symbol) and the eigenchannel coefficient Armk denote the number of bits transmitted over the M^{th} subcarrier using the R^{th} eigenchannel. Transmitted with power Prmk (the highest modulation order) allowed to be carried by an eigenchannel. The resource allocation problem can then be stated as

$$\arg_{Armk,}\min_{Prmk}\sum_{m=1}^{M} A_{rmk}\, P_{rmk} \quad (3)$$

Mathematical Description

The performance of the proposed RA algorithms for GS precoder is evaluated. The average power P_B is normalized by that of the single-user case, i.e., when a single user has access to all eigenchannels and all subcarriers.

$$P_{B=}10\log_{10}\frac{\text{Average transmitted power for modulation scheme}}{\text{Average trandmitted power for single user case}}$$

A Space/Frequency Allocation Algorithm

Step1: First determines the required eigenchannel number for each user.

Step 2: initially allocates zero bit to all subcarriers and then allocates bit by bit to the subcarrier which requires the least additional transmit power. The allocation process repeats until all data rate requirements are satisfied. Then we use the conventional bit-loading algorithm to allocate bits over each user's eigenchannel subset and compute the required transmit power.

B Constraint-Relaxation based Greedy Search Algorithm

Step1: The Constraint-Relaxation based Greedy Search Algorithm begins with a fair initial condition that gives all users the opportunity to access all its eigenchannels over all subcarriers.

Step2: Each user uses a bit-loading algorithm to obtain the local power minimization solution based on the allocated eigenchannel subset. The algorithm 2 has better performances when comes with Algorithm 1.

4. Results and Discussion

In this system consider 2 × 4 (4 antennas at the BS and 2 antennas at each MS) The system has six different modulation modes, BPSK, QPSK, 8QAM, 16QAM, 32QAM, and 64 QAM, 128 QAM respectively. For simplicity, we assume that the required data rate and BER are the same for all users.

In Fig. 1, The uplink transmission is considered and compare the performance of the proposed algorithms with that of the adaptive zero-forcing MIMO-OFDMA receiver proposed in and its non-adaptive counterpart is compared. Algorithm I (the efficient space/frequency resource allocation algorithm) is superior to the adaptive MIMO-OFDMA ZF approach by a 5 dB margin and Algorithm II (the constraint-relaxation based greedy search algorithm)(Q. H. Spencer *et al*, 2003) .

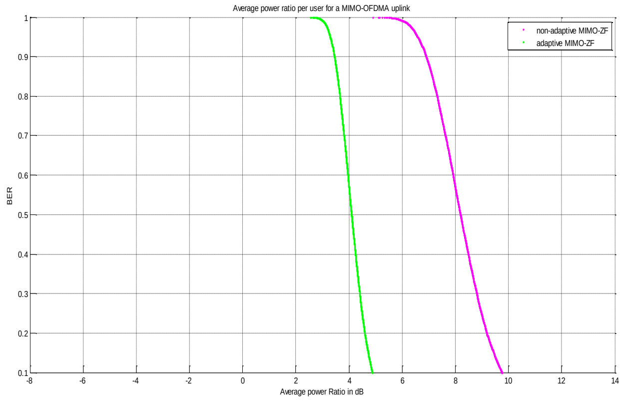

Fig 1: Average power ratio per user for a MIMO-OFDMA uplink; 32 subcarriers, 64 bits per OFDM symbol, 2 users.

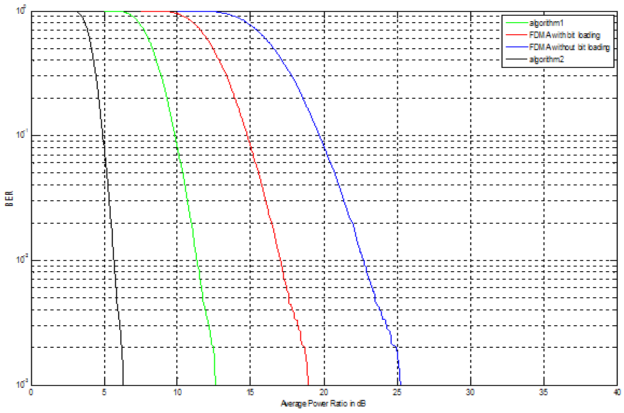

Fig 2: Average power ratio per user for a MIMO-OFDMA downlink; 32 subcarriers, 64 bits per OFDM symbol, 4 users.

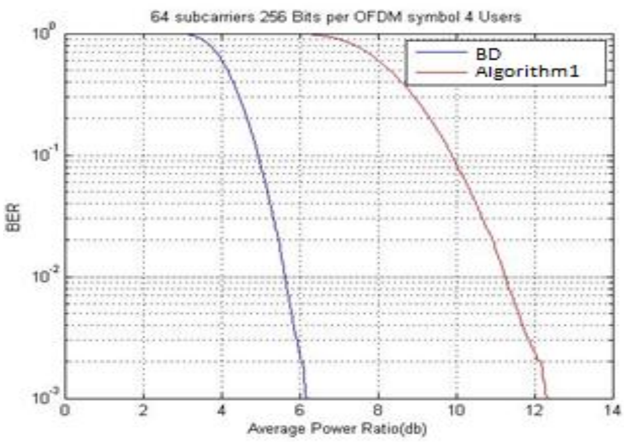

Fig 3: Average power ratio per user for a MIMO-OFDMA downlink; 64 subcarriers, 128 bits per OFDM symbol, 4 users.

In Fig. 2, The downlink transmission is considered. The performance of the FDMA scheme and proposed algorithm are compared. For the FDMA scheme (without bit-loading), the subcarriers are allocated to the users like the classical FDMA scheme according to their data rate requirements. The above figure shows that algorithm 1 and algorithm 2 offer 7dB margin. While compare the result of FDMA with bit loading and without bit loding,with bit loading is better .As the same way the algorithm 1 is better.

Fig 3 Shows the proposed precoding scheme. The BD approach is performing when desired data rate is 64 or128 bits per OFDM symbol. That BD outperforms the proposed precoding scheme by almost 6.2 dB with rate requirement of 256 bits/symbol.

In this figure BER for Block Diagonalization and algorithm 1are compared. Result show that BD has lower BER than algorithm 1.

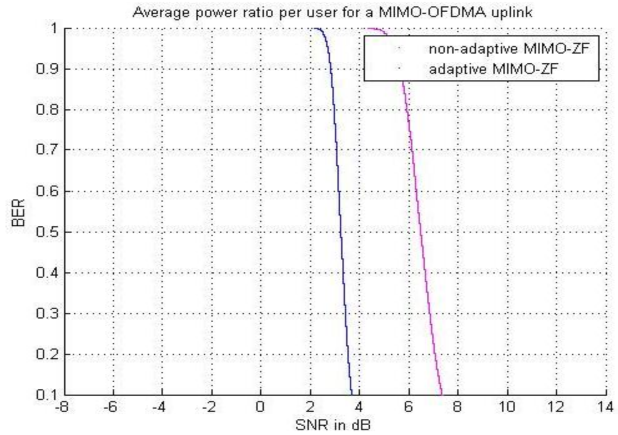

Fig 4: Average power ratio per user for a MIMO-OFDMA uplink; 32 subcarriers, 128 bits per OFDM symbol, 4 users.

In Fig. 4,The uplink transmission is compared compare the performance of the proposed algorithms with that of the adaptive zero-forcing MIMO-OFDMA receiver proposed in and its non-adaptive counterpart. Algorithm I (the efficient space/frequency resource allocation algorithm) is superior to the adaptive MIMO-OFDMA ZF approach by a 3.5 dB margin and Algorithm II (the constraint-relaxation based greedy search algorithm) .

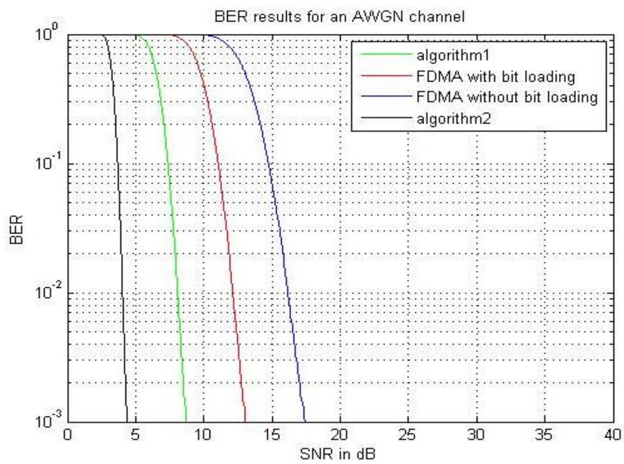

Fig 5: Average power ratio per user for a MIMO-OFDMA downlink; 32 subcarriers, 128 bits per OFDM symbol, 4 users.

In Fig. 5 The downlink transmission is considered. Compare the performance of the FDMA scheme and proposed algorithms are used For the FDMA scheme (without bit-loading), the subcarriers are allocated to the users like the classical FDMA scheme according to their data rate requirements. In this figure, the algorithm 1 and algorithm 2 has 4dB margin compared to FDMA with bit loading, FDMA without bit loading, the result shows algorithm 2 has lower BER to algorithm 1(Y.J. Zhang *et al*, 2002).

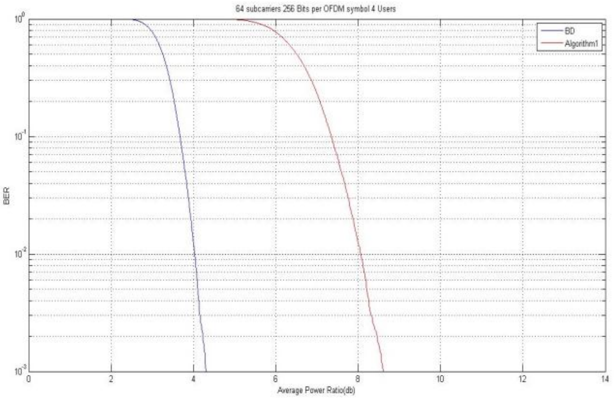

Fig 6 Proposed precoding scheme. The BD approach is performing when desired data rate is 64 or128 bits per OFDM symbol. That BD outperforms the proposed precoding scheme by almost 4.2 dB with rate requirement of 256 bits/symbol.

In this figure BER for Block Diagonalization and algorithm 1are compared. Result show that BD has lower BER than algorithm 1.

Conclusion

A Gram-Schmidt (GS) and SVD based precoding scheme for MIMO-OFDMA networks and two corresponding adaptive resource allocation algorithms. The precoder and the RA algorithms are designed to minimize total transmit power while satisfying the users' rate and error rate performance requirements. By dynamically controlling the eigenchannel allocation, power, and the modulation type, we exploit diversity gain in users, frequency and space domains. Simulation results show that the proposed centralized algorithms do provide near-optimal performance with practical complexity. More specifically, Algorithm I provides impressive performance gain while Algorithm II achieves better performance at the cost of higher complexity.

References

Chih-Lun Weng, Yuan-Bin Lin and Yu T.Su,(2010), Resource Allocation for MIMO-OFDMA Based Wireless network, TAIWAN IEEE comm. society vol. 10 pp. 201-204.

X. Lu Z. li, J. Cai and X. Chen (2009) An Adaptive Resource Allocation Algorithm Based on Spatial Sub channel in Multiuser MIMO/OFDM Systems, IEEE Int. Communications Conf. (ICC'08), pp. 4532-4536.

G. Liu, X. Liu and P. Zhang,(2008)QoS oriented dynamical resource allocation for eigen beamforming MIMO OFDM, IEEE Vehicular Technology Conf (VTC'05), vol.3 pp. 1450-1454.

M. Ergen, S. Coleri, and P. Varaiya,(2008)QoS aware adaptive resource allocation techniques for fair scheduling in OFDMA based BWA systems, IEEE Trans. Broadcasting vol 5 pp.112-118

M. S. Maw (2007)Resource Allocation Scheme in MIMO-OFDMA System for User's Different Data Throughput Requirements, IEEE Wireless Communications and Networking Conf. (WCNC'07), pp. 1706-1710.

Z. Hu, G. Zhu, X. Xiao and Z. Chen (2006)Resource allocation for multiuser space-time coding based OFDM systems with QoS provision, IEEE Vehicular Technology Conf. (VTC'05), Vol.4 pp. 2120-2123.

Y. H. Pan; S. Aissa, (2005) Dynamic Resource Allocation for Broadband MIMO/OFDM Systems IEEE Wireless Networks, Communications and Mobile Computing Conf., Vol.2 pp. 863-867.

S. Pietrzyk, G. J. M. Janssen, and P. Warsaw(2004)Radio resource allocation for cellular networks based on OFDMA with QoS guarantees, IEEE Global Telecommunications Conf.(GLOBECOM'04), vol. 4, pp. 2694-2699.

Q. H. Spencer, A. L. Swindlehurst and M. Haardt(2003)Zero-Forcing Methods for Downlink Spatial Multiplexing in Multiuser MIMO Channels IIEEE Trans. Sig. Proc.,,vol. 52, pp. 461-471.

Y.J. Zhang and K.B. Letaief (2002) Optimizing Power and Resource Management or Multiuser MIMO/OFDM Systems in Proc. Global Telecommunications Conf. (GLOBECOM'03), vol. 1, pp. 179-183.