ISSN 2395-695X (Print)
ISSN 2395-695X (Online)

International Journal of Advanced Research in Biology Engineering Science and Technology (IJARBEST)

Vol. 2, Special Issue 10, March 2016

SIMULTANEOUS BEAMFORMING IN MIMO-OFDM SYSTEM FOR NOISE TOLERANCE AND ERROR REDUCTION

Ms. N. NAGAJOTHI, IInd ME (Communication System),
Dr. S. KARTHIGAI LAKSHMI, Associate Professor/ECE
SSM Institute of Engineering and Technology, Dindigul, Tamilnadu, India
joejaiveena@gmail.com

ABSTRACT

In this project, three beamforming designs for multiple-input and multiple-output with orthogonal frequency-division multiplexing, where transmit and receive beamformers are obtained iteratively with closed-form steps. In the first step, the transmit (Tx) beamformers are set and the receive (Rx) beamformers are calculated. It works by projecting the Tx beamformers into a Null space of appropriate channels. Then the Rx beamformer for each user maximizes its instantaneous signal-to-noise (SNR) while satisfying an orthogonality condition to eliminate the interferences. The second step is optimizing the Tx and Rx beamformer by considering the SNR obtained from the first step. The third step is a joint optimization of Tx–Rx beamformers that combines SNR and signal-to-interference-plus-noise ratio maximization (SINR).

To optimize the minimum solution Genetic algorithm will be used which will provide a better performance by reducing the bit error rate (BER). This system provides faster beamforming and improved error performance.

1. Introduction

OFDM is a frequency-division multiplexing (FDM) scheme used as a digital multi-carrier modulation method. A large number of closely spaced orthogonal sub-carrier signals are used to carry data on several parallel data streams or channels. Multiple input, multiple output-orthogonal frequency division multiplexing (MIMO-OFDM) combines multiple input, multiple output (MIMO) technology, which multiplies capacity by transmitting different signals over multiple antennas, and orthogonal frequency division multiplexing (OFDM), which divides a channel into a large number of closely spaced sub channels to provide more reliable communications at high speeds. Research conducted during the mid-1990s showed that while MIMO can be used with other popular air interfaces such as time division multiple accesses (TDMA) and code division multiple access (CDMA), the combination of MIMO and OFDM is most practical at higher data rates.

MIMO-OFDM is the foundation for most advanced wireless local area network (Wireless LAN) and mobile broadband network standards because it achieves the greatest spectral efficiency and, therefore, delivers the highest capacity and data throughput.

2 Related Work

2.1 Improving MAC Efficiency

There has been a great amount of work on improving the MAC protocol efficiency by using frequency domain contention. FICA [9] tackles the inefficiency of the 802.11 MAC by redesigning both the PHY/MAC by using OFDM-based fine-grained channelization. The authors have proposed Back2F that migrates the time domain backoff to the frequency domain. As the frequency domain backoff lasts for several OFDM symbols, it reduces the relative MAC overhead, hence improves the MAC protocol efficiency. REPICK has modified the receiver to perform the frequency domain backoff instead of a transmitter and added a ACK piggybacking feature, which further reduces the MAC overhead. These work share the similarity of using the OFDM technique to enhance the MAC protocol efficiency. However, our work differs from them because D-Fi attempts to exploit the frequency diversity while reducing overhead by using the Bloom filter based channel contention/estimation.

2.2 Frequency Diversity

Many theoretic classic proposals that exploit frequency diversity are well summarized in the wireless communication textbook. Some of them are currently being used by cellular systems like WiMAX and 3GPP LTE. Recently, there are theoretic studies that apply proportional fair packet scheduling in FDMA-based 3GPP LTE [10], [7] and CSMA-based OFDMA systems. These work solves the resource allocation problem by mathematical modeling while assuming that the perfect channel quality information is available via the training sequence. Our work proposes a WLAN protocol that practically considers the channel estimation overhead. Many practical measurement studies have been conducted to show the existence of frequency diversity. Among these, the most relevant to our work are measurement studies in the 2.4 GHz/5GHz ISM bands [8]. Also, in WLANs, several frequency diversity-aware schemes have been proposed. The authors of [6] observed the frequency diversity in wide-band WLANs, and introduced a practical rate adaptation scheme based on the effective SNR (eSNR). In FARA, a transmitter can send multiple packets to multiple receivers concurrently based on the OFDM technique. Thus it does not need to consider the time-sync problem arisen when multiple packets are combined at a receiver. FARA can be used in the downlink of a WLAN and may be viewed complementary to our work, since we mainly focus on the uplink. Finally, the authors of [8] proposed a diversity-aware WLAN that uses an adaptive interleaver and an forward error correction (FEC) scheme based on per-subcarrier channel state information (CSI). It adopts different domain approaches such as a per-subcarrier FEC method and an interleaver and hence is orthogonal to our work.

2.3 Machine Learning

An explosive increase of digital data has led to the spotlight in the use of machine learning techniques to extract engineering information from voluminous data. In the field of networking, Internet application traffic classification has been conducted using Naïve Bayes, C4.5 decision tree or Naive Bayesian tree [4], and support vector machine (SVM) algorithms. The authors of [2] have performed the scientifically grounded performance comparison among the several methods including well known ML algorithms in terms of the classification accuracy. In the area of wireless networking, the authors of [3] have developed Airshark that extracts the signal level features using the functionality provided by a Wi-Fi card and identifies multiple non-Wi-Fi signals like Zigbee, cordless phone, Bluetooth, etc based on the SVM algorithm. To the best of our knowledge, our work is the first workthat applies ML methods to a PHY/MAC WLAN protocol.

2.4 Multi-Armed Bandit Problem

There are many theoretical studies on the multi-armed bandit problem [5], [11]. Lai and Robbins found that there exists a solution, called an index-type policy, that achieves expected regret that grows asymptotically as log T. A Markovian model is generally considered to study the MAB problem. In Markovian models, the state of each arm evolves according to an underlying transition probability matrix when the arm is played. It is called rested Markovian bandit problem and [1] has found an index-policy that solves the problem with asymptotic optimality. In this paper, we focus on the stateless case, since wireless channels are random with time and hence cannot be easily modeled as stateful cases. In the area of wireless networking, the authors of [5] have developed Simple- MAC that balances the exploration versus exploitation tradeoff in an attacker-exposed wireless network. In cognitive radio networks, wireless channel allocation problem is solved under the MAB framework [11]. In D-Fi, we extend the greedy algorithm, to be applied to the case that multiple decentralized users play with multiple arms yielding i.i.d rewards.

3. Beam Forming and Genetic Algorithm

Beam forming is a signal processing technique used for directional signal transmission or reception. This is achieved by combining elements in a phased array in such a way that signals at particular angles experience constructive interference while others experience destructive interference.

To change the directionality of the array when transmitting, a beam former controls the phase and relative amplitude of the signal at each transmitter, in order to create a pattern of constructive and destructive interference in the wave front. When receiving, information from different sensors is combined in a way where the expected pattern of radiation is preferentially observed.

3.1 Beam Forming In Mimo-OFDM System

Beam forming in MIMO-OFDM is for communications between pairs of terminals where there are several pairs sharing the spectrum simultaneously. Each multi-antenna transmitter strives to direct its data to only one multi element receiver in the presence of interference from all the other users_ transmitters.

It works by projecting the Transmit beam formers into a null space of appropriate channels [12]. This eliminates one interference term for each user. Then the Receive beam former for each user maximizes its instantaneous signal to-noise ratio (SNR) while satisfying an orthogonality condition to eliminate the remaining interferences. Then jointly optimizing the Transmit and Receive beam formers from constrained SNR maximization. At last for joint optimization of Transmit – Receive beam formers but combines constrained SNR and signal-to-interference-plus-noise ratio maximization.

3.2. Genetic Algorithm

A **genetic algorithm** (GA) is a method for solving both constrained and unconstrained optimization problems based on a natural selection process. The **algorithm** repeatedly modifies a population of individual solutions. To Optimizing the minimal Solution Generic Algorithm is used to obtain. The Steps For Genetic Algorithm are below:

- Generate the next population with number of iterations
- Initialize the population | |
- Mutation | |
- Cross over | |
- selection | |
- Termination | |
- Generate the next population with number of iterations

These steps were undergone to obtain the optimal minimal solution.

4. Simultaneous Beamforming In Mimo-Ofdm System

In order to improve the error performance three beams forming designs for multiuser multiple-input and multiple-output with orthogonal frequency-division multiplexing. Transmit and receive beam formers are obtained iteratively with closed-form steps.

Initially, the transmit (Tx) beam formers are set and the receive (Rx) beam formers are calculated. It works by projecting the Tx beam formers into a null space of appropriate channels. This eliminates one interference term for each user. Then the Rx beam former for each user maximizes its instantaneous signal-to-noise ratio (SNR) while satisfying an orthogonality condition to eliminate the remaining interferences.

Then jointly optimizing the Tx and Rx beam formers from constrained SNR maximization. It uses the results from the first case.

Finally is for joint optimization of Tx–Rx beam formers but combines constrained SNR and signal-to-interference-plus-noise ratio maximization. The minimum number of antennas required is derived as part of the formulation. There are multi-antenna terminals which are striving to share simultaneously the spectrum in time and space. The first channel model justifies both the MIMO-OFDM configuration and deploying the multi-path precoder. The second channel model is used only to compare the performance of the existing methods with our three proposed designs. Initially the parameters are set as follows:

i.t = 0:0.001 :(0.001*P*L*K); for Time, sampling frequency is 1 kHz
ii.N=length (t); for number of samples
iii.s=round (rand (N, 1));

Assuming perfect OFDM symbol timing synchronization, then after removal of the cyclic prefix with length from round matrix and after the FFT,
the received signal vector for the i_{th} user can be written: K

$y_i(p) = H_{i,i}(p)v_i(p)s_i(p) + \sum H_{i,i\_}(p)v_{i\_}(p)s_{i\_}(p) + n_i(p)$……….........(1)

In order to have good detection performance for all users in MIMO interference channels is the subject of widespread interest

$SNRi = Si/Ni$ ……..……… (2)

4.1. Beam Forming At Transmitter

In this the optimal receive - beam formers for constrained SNR Maximization when the transmit-beam formers are known type of calculating the beamforming at transmitter. The Transmit-BeamFormers are found from the null space of an appropriate set of channels, and then the optimal Receive-BeamFormers are sought.

Constrained SNR maximization formulation where maximization over a quasi-convex object function with affine constraints is sought. It has sets of solutions for local maxima.

This Local minimum has been calculated from the Genetic Algorithm which undergone some steps are given as:

- Initialization | |
- Creation of Random population | |
- Evaluation of fitness of population
- Sorting the population according to their fitness
- SELECTION
- CROSSOVER
- genomes are exchanged during crossover
- MUTATION
- ELIMINATION

The optimum Rx-BF is in closed-form for the constrained SNR maximization problem where the Transmit-BeamFormers are the null space of the appropriate channels.

This optimization problem is denoted *P* for the first receiver, Multipath diversity can be also added. Following the design procedure in this section and deploying **Φ**, then with the subcarrier index is:

$$\mathbf{u}^{H1}(p)\mathbf{y}^{1}(p) = \mathbf{u}^{H1}(p)\mathbf{H}1,1(p)\mathbf{v}^{1}(p)s^{1}(p) + \mathbf{u}^{H1}(p)\mathbf{n}^{1}(p) \ldots\ldots\ldots\ldots\ldots(3)$$

The u^{H1} (p) y_1 (p)_s stacked for all P subcarriers and then this received OFDM frame is decoded by SD. Hence, instead of decoding $s_1(p)$ subcarrier-wise (if $\Phi = I_{P\times P}$), using the LCP matrix makes it possible to decode the data frame-wise while getting multipath diversity.

4.2. Beamforming At Receiver

In this Beamforming at Receiver the same steps will be undergoes as like the beamforming at transmitter.The optimal Transmitter - beam formers for constrained SNR Maximization when the receive-beam formers are known type of calculating the beamforming at Receiver.

The Transmit-BeamFormers are found from the null space of an appropriate set of channels, and then the optimal Receive- BeamFormers are sought.

Constrained SNR maximization formulation where maximization over a quasi-convex object function with affine constraints is sought. It has sets of solutions for local maxima.

This method is based on adding redundant bits to information to reduce the ISI. Like the basic precoder schemes here also channel side transfer function is known at both the transmitter and receiver side. The precoding operation is done by using modulo operator and set of block filters, whose parameter decides the number of redundant bits that is to be added to the information bits to avoid ISI. At the receiver side the inverse of modulo operator along with frequency domain equalization helps in determining the information bits.

MIMO-OFDM is a widely used technology in wireless communication and even though it has many advantages such as high bandwidth efficiency and higher bit rate, the problem of insufficient cyclic prefix is a major issue. The study of different methods to reduce ISI shows that insufficient cyclic prefix is no more an issue in MIMO-OFDM system. All the system design that we studied eliminates ISI completely and helps in attaining high data rate.

The optimum Tx-BF is in closed-form for the constrained SNR maximization problem where the Receive-BeamFormers are the null space of the appropriate channels.

4.4. Joint Beamforming At Transmitter-Receiver

The optimal closed-form Receive-BeamFormers were obtained by while the Transmit-BeamFormers are the null space of channels according to an even or odd number of users, respectively. In this joint Transmit-BeamFormers and Receive-BeamFormers are designed for the constrained SNR maximization problem by using the Genetic algorithm for a multi-objective optimization

Consider the following optimization :

$$\text{Min} \quad J(\mathbf{x}) = J_1(\mathbf{x}_1 \ldots \mathbf{x}_K) + \ldots + J_K(\mathbf{x} \ldots \mathbf{x}_K) \ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Transmit-BeamFormers and Receive-BeamFormers design for joint constrained SNR maximization and SINR maximization is Receive-BeamFormers nulls its interference and then this solution is inserted to the constrained SNR objective function which yields the Transmit beamformer. In this Joint beamforming at transmitter-receiver, multi objective optimization is applied..

4.3. Feedback Rate

Feedback rate of proposed beamforming method in comparison with other Beamforming schemes for interference channels are given. beamforming is the amount of information required to be exchanged among receivers and transmitters, which bites into the payload capacity.

The feedback of the presented beamforming is compared with existing interference channel beamforming schemes. The analysis is for flat channels, and is extended to OFDM via scaling by *P*. It is emphasized that the feedback rate, complexity and performance are competing factors in *K*-user interference channels.

A key advantage of OFDM is that fast Fourier transforms (FFTs) may be used to simplify implementation. Fourier transforms convert signals back and forth between the time domain and frequency domain. Consequently, Fourier transforms can exploit the fact that any complex waveform may be decomposed into a series of simple sinusoids. In signal processing applications, discrete Fourier transforms (DFTs) are used to operate on real-time signal samples. DFTs may be applied to composite OFDM signals, avoiding the need for the banks of oscillators and demodulators associated with individual subcarriers. Fast Fourier transforms are numerical algorithms used by computers to perform DFT calculations.

FFTs also enable OFDM to make efficient use of bandwidth. The subchannels must be spaced apart in frequency just enough to ensure that their time-domain waveforms are orthogonal to each other. In practice, this means that the subchannels are allowed to partially overlap in frequency. information (CSI). When the transmitter does possess CSI (which can be obtained through the use of training sequences), it is possible to approach the theoretical channel capacity. CSI may be used, for example, to allocate different size signal constellations to the individual subcarriers, making optimal use of the communications channel at any given moment of time.

More recent MIMO-OFDM developments include multi-user MIMO (MU-MIMO), higher order MIMO implementations (greater number of spatial streams), and research concerning massive MIMO and CooperativeMIMO for inclusion in coming 5G standards.

Multi-user MIMO beamforming even benefits single spatial stream devices. Prior to MU-MIMO beamforming, an access point communicating with multiple client devices could only transmit to one at a time. With MU-MIMO beamforming, the access point can transmit to up to four single stream devices at the same time on the same channel.

5. Performance Analysis

The technique of Simultaneous Beamforming in MIMO-OFDM for Noise Tolerance and Error Reduction is simulated using Matlab R2014a. Matlab is appropriate software for analysis the work done evaluation of results for MIMO-OFDM.

Symbol	Name	Value
P	Number of Subcarriers	16
K	Number of Users	4
N_r	Receiving Antenna	4
Nt	Transmitting Antenna	4
L	Channel Length	8
J	Rotation Matrix	8

Table 5.1 Initial System Parameters

The BER performance and computational complexity of proposed methods have been obtained. The key benefit of the presented beamforming approaches is their computational simplicity. The sum rate maximization by Rotational Matrix discussed.

The bit error rate performance of the optimized beamformers is depicted are: Rx-BF design for constrained instantaneous SNR maximization while the Tx-BFs are fixed and Tx-

BFs null one interference term. joint Tx-BF and Rx-BF design for instantaneous SNR maximization.Joint Tx-BF and Rx-BF design for instantaneous SNR and SINR maximization.

6. Conclusion and Future Work

In this Project, faster beamforming and improved error performance has been obtained for a MIMO-OFDM interference channel. With a unit norm to transmit and receive beamformers, the algorithms comprise iterative procedures with closed-form steps allowed a faster solution. It is known that to optimize the solution Genetic algorithm were used which still improved the performance. The results of this project have viewed as some quantification of the trade-offs of between algorithmic simplicity for each stage and feedback rate, in beamforming for the MIMO-OFDM interference channel.

In future, improving optimal solvers with Interior point linear programming solver for beamforming in MIMO-OFDM systems with various parameters.

REFERENCES

[1] D. Kalathil, N. Nayyar, and R. Jain, “Decentralized learning for multi-player multi-armed bandits,” in Proc. IEEE 51st Annu. Conf. Decision Control, 2012, pp. 3960–3965.

[2] S. Lee, H. Kim, D. Barman, S. Lee, C.-k. Kim, T. Kwon, and Y. Choi, “NeTraMark: A network traffic classification benchMark,” ACM SIGCOMMComput. Commun. Rev., vol. 41, no. 1, pp. 22–30, 2011.

[3] S. Rayanchu, A. Patro, and S. Banerjee, “Airshark: Detecting non- WiFi RF devices using commodity WiFi hardware,” in Proc. ACM SIGCOMM Conf. Internet Meas. Conf., 2011, pp. 137–154.

[4] D. M. Farid, N. Harbi, and M. Z. Rahman, “Combining Naïve Bayes and decision tree for adaptive intrusion detection,” Int. J. Netw. Security Its Appl., vol. 2, no. 2, p. 12, 2010.

[5] S.-Y. Chang, Y.-C. Hu, and N. Laurenti, “SimpleMAC: A jamming- resilient MAC-layer protocol for wireless channel coordination,” in Proc. 18th Ann. Int. Conf. Mobile Comput. Netw., 2012, pp. 77–88.

[6] D. Halperin,W.Hu, A. Sheth, and D.Wetherall, “Predictable 802.11 packet delivery from wireless channel measurements,” ACM SIGCOMMComput. Commun. Rev., vol. 41, no. 4, pp. 159–170, 2011.

[7] H. Yang, F. Ren, C. Lin, and J. Zhang, “Frequency-domain packet scheduling for 3GPP LTE uplink,” in Proc. 29th Annu. IEEE Int. Conf. Comput. Commun., 2010, pp. 1–9.

[8] A. Bhartia, Y.-C. Chen, S. Rallapalli, and L. Qiu, “Harnessing frequency diversity in multicarrier wireless networks,” in Proc. 17th Annu. Int. Conf. Mobile Comput. Netw., 2011, pp. 253–264.

[9] K. Tan, J. Fang, Y. Zhang, S. Chen, L. Shi, J. Zhang, and Y. Zhang, “Fine grained channel access in wireless LAN,” ACM SIGCOMM Comput. Commun. Rev., vol. 41, no. 4, pp. 147–158, 2011.

[10] J. Huang, F. Qian, Y. Guo, Y. Zhou, Q. Xu, Z. M. Mao, S. Sen, and O. Spatscheck, “An in-depth study of LTE: Effect of network protocol and applicationbehavior on performance,” in Proc. ACM SIGCOMM Conf., 2013, pp. 363–374.

[11] Y. Gai, B. Krishnamachari, and R. Jain, “Learning multiuser channel allocations in cognitive radio networks: A combinatorial multi-armed bandit formulation,” in Proc. IEEE Symp. New Front. Dyn. Spectr., 2010, pp. 1–9.

[12] Suchul Lee, Jaehyuk Choi, Joon Yoo, and Chong Kwon Kim, "Frequency Diversity-Aware Wi-Fi Using OFDM Based Bloom Filters", IEEE Transactions On Mobile Computing, Vol. 14, No. 3, March 2015