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# Review on Channel Capacity Enhancement in MIMO OFDM Wireless System

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***Abstract:*** ***With the rapid enhancement in wireless communication systems, the systems are expected to provide high data rates for high quality multimedia services. For high data rate achievement one must enhance the capacity of the wireless communication system. The capacity of a communication system can be enhanced by using MIMO and OFDM system. MIMO OFDM is commonly used for communication system due to its high transmission rate and robustness against multipath fading. This paper review on different channel capacity enhancement techniques used in MIMO OFDM system are SVD(Singular Value Decomposition), water Filling algorithm, Forward Error Correction, least square method Optimal Training Sequence and RLMS(Recursive Least Mean Square).***

***Keywords: MIMO (Multiple Input and Multiple Output), OFDM (Orthogonal Frequency Division Multiplexing), Water Filling Algorithm, ISI (Inter Symbol Interference), channel capacity.***

## I. INTRODUCTION

The growing demand on wireless communication service has created the necessity to support higher data rates.[1]As next generation wireless communication networks are expected to provide broadband multimedia services such as voice, web browsing, video conferencing etc. with diverse quality of service requirements. So as to enhance the capacity of fading channels the MIMO and OFDM system are combined to form hybrid system which increase the capacity of wireless system. Capacity is the measure of maximum information that can be transmitted reliably over a channel. The capacity of communication system can be enhanced using MIMO system and OFDM system.[3]Wireless communication system face high level of ISI and to improve the capacity and spectral efficiency (bps/Hz) in wireless system OFDM technique is used in which guard band and cyclic prefix are introduced to mitigate ISI. Usually fading is considered as a problem in wireless communication but MIMO system uses fading to increase the system capacity. MIMO is a promising technique to increase the system capacity with acceptable BER by using the number of antennas at the transmitter and the receiver. A MIMO OFDM system transmits OFDM modulated data from multiple antennas at transmitter. Data transmitted with subcarrier at different antennas which are orthogonal to each other. The receiver extracts the different data stream from different sub carriers after OFDM demodulation and MIMO decoding.[8] System capacity can be further enhanced by using water filling algorithm ,singular value decomposition and many other techniques which considerably enhances the capacity of the wireless communication system. Water filling algorithm states the division of total power in such a way that a greater portion of power goes to sub channel with higher gain and less or even none to the channel with small gain. SVD (Singular Value Decomposition) technique decouples the channel matrix in spatial domain. [8] MIMO OFDM systems are best choice for increasing the capacity of wireless communication system because of characteristics like reduced ISI, reduced ICI (Inter carrier interference), optimized power consumption and easy transmission of symbol in time, frequency and space. MIMO OFDM system suffer from disadvantages like PAPR(peak average and peak ratio), frequency and phase noise sensitivity making it difficult for wireless LAN battery power to operate for longer period of time, pre coding scheme for multi user system and also have some computational

 

complexity. OFDM and MIMO system is widely used in system such as Wi-Fi (802.11a/g/n) and WiMAX (802.16) and used in next generation communication. Many other wireless and wire line applications such as DAB (Digital Audio Broadcasting), DVB-T (Digital video broadcasting), Hiper LAN/2, ADSL (Asymmetric Digital Subscribe Line) and future use in 5G communication.[12]

## II. Related Work

L. Ameta et.al[1] had proposed the iterative water filling algorithm to enhance the channel capacity of MIMO OFDM system. The simulation had been carried out on MATLAB 2010a using different antenna arrangements over Rayleigh, Rician and Nakagami fading channels. Moreover bit error rate (BER) performance of MIMO OFDM system had been compared over different modulation schemes.

R. Hidayat et.al[2] had proposed channel estimation for spatial multiplexing was investigated for MIMO OFDM system. Pilot symbols were used to gather knowledge about the channel about the channel and try to estimate it. The channel estimation based on pilot symbol is called pilot aided channel estimation. In that research, Least Square (LS) method was chosen for initial channel estimation. Zero Forcing (ZF) algorithm was used to detect and separate the received signal. The result showed that channel estimation would be better by increasing SNR.

H. Deshmukh et.al[5] had implemented water filling algorithm for allocating power to the MIMO channels for enhancing the capacity of the MIMO network. The water filling algorithm had provide solution with the help of channel state information. The singular value decomposition and water filing algorithm had been employed to measure the performance of MIMO OFDM integrated system.

Md.Rahim et.al[8] had presented the singular value decomposition and water filling algorithm had been employed to measure the performance of MIMO OFDM integrated system. Therefore, the capacity was increased by transmitting different streams of data through different antennas at a same carrier frequency. Any Inter Symbol Interference (ISI) produced after the transmission was recovered by using spatial sampling integrated with signal processing algorithm.

H.Wang et.al[6] had proposed optimal cooperative water filling algorithm for power allocation in OFDM system. The transmitter first cooperate by sharing CSI (channel sate information) and then jointly optimize power allocation in the metric of sum throughput, which could be modelled as a convex optimization problem. Based on the solution, the optimal cooperative power allocation algorithm was constructed, the structure of which could be explained as a cooperative water filling relative to the traditional water filling.

## III. Capacity Enhancement Techniques

Different techniques used for channel capacity enhancement are

A. Singular Value Decomposition

B. Water Filling Algorithm

Variants of water filling algorithm are

1. Iterative Water Filling Algorithm
2. Improved iterative Water Filling Algorithm
3. Centralized Iterative Water Filling Algorithm
4. Cluster Water Filling Algorithm
5. Cooperative Water Filling Algorithm

 

6. Genetic Algorithm based Water Filling

C. FEC (Forward Error Correction)

D. Least Square Method

E. Optimal Training Sequence

F. RLMS (Recursive Least Mean Square)

### *A. Singular Value Decomposition (SVD)*

SVD decomposes a single user system MIMO channel into multiple parallel sub channels, and then transmitting power can be distributed to these sub channels to obtain channel capacity. SVD decouple the channel matrix into spatial domain as DFT coupling the channel in frequency domain. This is an important technique to exploit the full capability of MIMO OFDM wireless system. [8]

### *B. Water filling algorithm*

Water filling algorithm is a general name given to the ideas in communication system design and practise for equalization. As name suggests, just as water find its level even when filled in one part of a vessel with multiple opening as a consequence of Pascal's law. Water Filling is used to determine the power transmitted in each channel to achieve greatest possible capacity. Water filling is the solution of various optimization problem related to channel capacity. Water filling algorithm solves the problem of maximum mutual information between input and output of a channel.

1. *Iterative Water Filling Algorithm*: In order to find the exact value of water level iterative water filling was proposed. As without water filling the total power is allocated equally between all sub carriers. Water filling algorithm allocates power among all the sub carriers according to channel gain that greater portion of power goes to sub channel with higher gain and less or even none to the channel with small gain. Iterative water filling algorithm converges to get the optimal solution. When there is negative value of power allocation stop iterations.[1],[3],[5]

2. *Improved Iterative Water Filling Algorithm*: As iterative water filling power allocation among all the users could result in large computational complexity. To get the quick and accurate calculation of channel capacity and diversity. Its basic idea is to select a small number of active users, and then to allocate the total power among the effective users using water filling algorithm, thus to compute the channel capacity.[10]

3. *Centralized Iterative Water Filling Algorithm*: This algorithm maximizes the system capacity throughput subject to per Base Station power constraints in downlink OFDM network. It is assumed that central unit could get access to perfect channel state information and data of all users.[2]

4. *Cluster Water Filling Algorithm*: Water Filling gives solution to only subcarrier while for the whole sub carrier it is not water filling, as value of power may vary from one sub carrier to other named as Cluster Water Filling because in each cluster value of power does not vary. Cluster water filling was proposed to solve the problem of robust transceiver design as robust design is better than non robust design.[7]

5. *Cooperative Water Filling Algorithm*: In cooperative water filling two transmitter and multiple receiver were employed to maximize the capacity of the system as one receiver should jointly transmitted by two transmitters, and all other receivers are transmitted only by one of two transmitters. Transmitters have their own perfect CSI (Channel State Information), first cooperate by exchanging CSI and then jointly optimize the power allocation in the metric of sum throughput (capacity).[6]

6. *Genetic Algorithm based Water Filling:* Water Filling algorithm maximize the bit rate for entire MIMO-OFDM transmission system and genetic algorithm is a biologically inspired technique inspired by natural evolution such as

 

inheritance, selection and crossover. Water Filling is combined with genetic algorithm to find the optimum power vector that maximize the overall throughput of OFDM system while satisfying the total power constraints, bit allocation and in addition to quality of service.[13]

### *C. FEC (Forward Error Correction) Technique*

FEC is the way of adding redundant bits so that errors can be detected easily and corrected without the need of retransmission but at the cost of increased bandwidth which can be overcome by puncturing. Puncturing reduce the number of redundant data to be transmitted by making use of puncturing matrix. FEC performs better than other conventional techniques. [4]

### *D. Least Square Method*

This method was chosen for initial channel estimation because only a few channel characteristics are known at the receiver based on pilot symbol subcarrier. Based on initial channel estimation it can obtain the overall channel estimation through the use of channel information. The estimated channel capacity has the value that is close to the known channel capacity. [9]

### *E. Optimal Training Sequence*

Optimal training sequence carefully selects the training sequences to eliminate inter antenna interference. Training sequence not only simplifies the initial channel estimation but also attain the best estimation performance. Optimal training sequence is used to obtain initial channel parameters, timing and frequency offset. Optimal training sequence technique is more flexible than other techniques. [11]

### *F. RLMS (Recursive Least Mean Square) Technique*

To get higher accuracy and precision in channel estimation a new technique RLMS was proposed which is the combination of LMS (Least Mean Square) and RLS (Recursive Least Square) algorithm. LMS is adaptive channel estimation technique used for system identification. This is a simple technique but has slow convergence speed. RLS means that LS (Least Square) is used recursively in which previously calculated estimates are used to find the new estimate. RLS provide high rate convergence but have large computation complexity. So both of these techniques are combined to get a new technique which overcome these disadvantages is RLMS. In RLMS algorithm the error signal of one LMS algorithm is fed back to other RLS algorithm, so the weight vectors are updated twice that is first time by RLS and second time by LMS. Thus combined method increases the convergence speed and provide low error rate than single LMS and RLS algorithm for system capacity enhancement. [14]

## IV. CONCLUSION

In this paper, it is concluded that MIMO OFDM is a promising technique for achieving high data rate for next generation communication system. So we discuss the different technique which significantly enhances the capacity of the MIMO OFDM wireless communication system. The various techniques which we discussed have their own advantages and disadvantages.

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