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A BEAMFORMING ALGORITHM FOR COLLABORATIVE MIMO SYSTEM WITH ARRAY ANTENNA

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ABSTRACT

Collaborative spatial multiplexing (CSM) allows individual handsets to transmit each signal at the same carrier and same time as independent signals are transmitted through each antenna of one device in MIMO system. In this paper, we propose algorithm to combine CSM and beamforming technique for OFDM system. When the base station has 8 antenna elements, it is observed that the BER is improved by 6 dB compared to CSM without beamforming. In order to detect MIMO signals, we adopt ML (Maximum Likelihood) detection.

1. INTRODUCTION

Various multiple-antenna schemes have been proposed in order to increase the channel capacity or to improve the link reliability. Spatial multiplexing type of MIMO scheme can increase transmission rate without increasing bandwidth and transmit power. In particular, CSM is a MIMO scheme that allows two different mobile stations to transmit independent data streams to the base station on the same carrier and on the same time through each antenna of the mobile station. In the mean time, beamforming is another type of multi-antenna technique which increases capacity of base station and transmission rate where each antenna compensates magnitude and phase of received signal, thus SNR gain is obtained. In this paper we propose CSM structure combined with beamforming to take advantages of two schemes so that diversity gain and throughput increase can be obtained simultaneously.

We assume that base station has two groups of antennas. Distance between antennas in each group is short enough so that spatial correlation between antenna elements becomes high. And, mobile stations are separated from each other, so their steering vectors are considered as independent each other.

We propose the algorithm to combine CSM and beamforming technique for OFDM system. The algorithm uses weight combining for the channel estimation. The estimated channel and weight can change proposed system model to 8x2 MIMO system.

This paper is organized as follows. In Section 2, we introduce basic theory of multiple antennas. In Section 3, we describe system model. In section 4 we show proposed algorithms. In section 5 we show performance of proposed algorithms based on IEEE 802.16e standard. Conclusions are given in Section 6.

2. MULTIPLE-ANTENNA SCHEMES

In this section, we introduce the principles of CSM and beamforming technique before mentioning proposed algorithm.

2.1 Collaborative Spatial Multiplexing (CSM)

MIMO scheme uses multi-antenna and improve performance of transmission rate because this scheme obtains diversity gain.

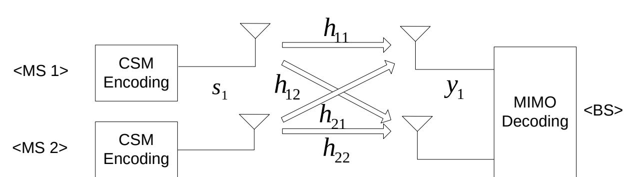

Figure 1. 2x2 C.MIMO block

Figure 1 shows example of CSM system consisting of two mobile stations and one base station where each mobile station has single antenna and base station has two antennas. Each mobile station can transmit independent data on the same time and the same frequency. At the base station, received signal vector can be expressed as below.

There are various detection techniques for the MIMO system. Linear detection based on Zero Forcing (ZF) and

Minimum Mean Square Error (MMSE) or Nonlinear detection algorithm such as SIC (Successive Interference Cancellation) is normally referred as MIMO detection scheme. As mentioned before, Maximum Likelihood (ML) outperforms other detection schemes at the cost of high computational complexity.

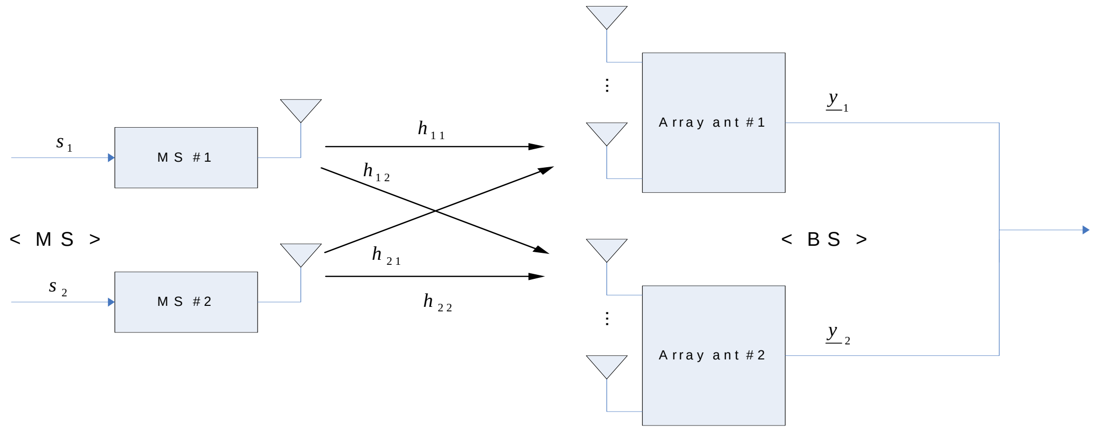

Figure 2 Block Diagram of System Model

2.2 BF

Beamforming is another technique which can increase channel capacity and transmission rate. At the base station, multiple replica of transmitted signal is arrived with certain time delay and different magnitude and phase, i.e. multi-path channel propagation. All of these multiple signals through the each path are summed in base station. If base station has multiple antennas, there is difference between each received signal. Beamforming is a technique obtaining SNR gain by calculating weight vector and compensating for the received signal properly. Interference signals can be also decreased.

3. SYSTEM MODEL

A system model is introduced to verify the performance of proposed algorithm in this section Figure 2 shows system model of CSM system combined with beamforming. Two mobile stations are positioned separately and they transmit their own data stream via antenna to the base station where steering vectors between mobile stations are independent. Base station has two beamforming antenna groups and each group consists of four antennas. Antenna spacing in each group is assumed to be half-lamda long. Received signals at each antennas in the same group are highly correlated since antenna spacing is close enough. The difference of received signal magnitude and phase at each antenna can be expressed as a steering vector (i : MS index , j : BS Antenna group index)

Assuming each antenna groups are spaced far enough and incident signals on the base station antennas experiences Rayleigh frequency-flat fading channels, received signals can be modeled as below.

Where (i : MS index , j : BS Antenna group index) and (i : MS index) denotes channel and transmitted signal respectively. (j : BS Antenna group index) represents AWGN (Addictive White Gaussian Noise)

4. PROPOSED ALGORITHM

Figure 3 is block diagram of proposed algorithm. (i : MS index , j : BS Antenna group index) denotes weight vector. Other signs are same to previous section.

We propose CSM structure combined with beamforming to take advantages of two schemes so that diversity gain and SNR gain can be obtained simultaneously. We can estimate weight vector that is almost same compared to steering vector. We use Lagrange algorithm to estimate weight, that algorithm maximize signal power. Received signals are combined with those weight vectors. Channel information is estimated from the combined signals. Finally, we can make 8x2 MIMO system using received signals, weight vectors and channel information. Among the various detection techniques for the MIMO system, we adopt ML detection. ML detection for proposed model is expressed as below

denotes the set of all possible transmit data vectors. Transmit data is estimated from principle of minimization of the Euclidean distance.

5. SIMULATION RESULTS

Based on IEEE.802.16e spec, computer simulation is progressed on proposed algorithm.

- IEEE.802.16e Uplink
- Modulation : QPSK

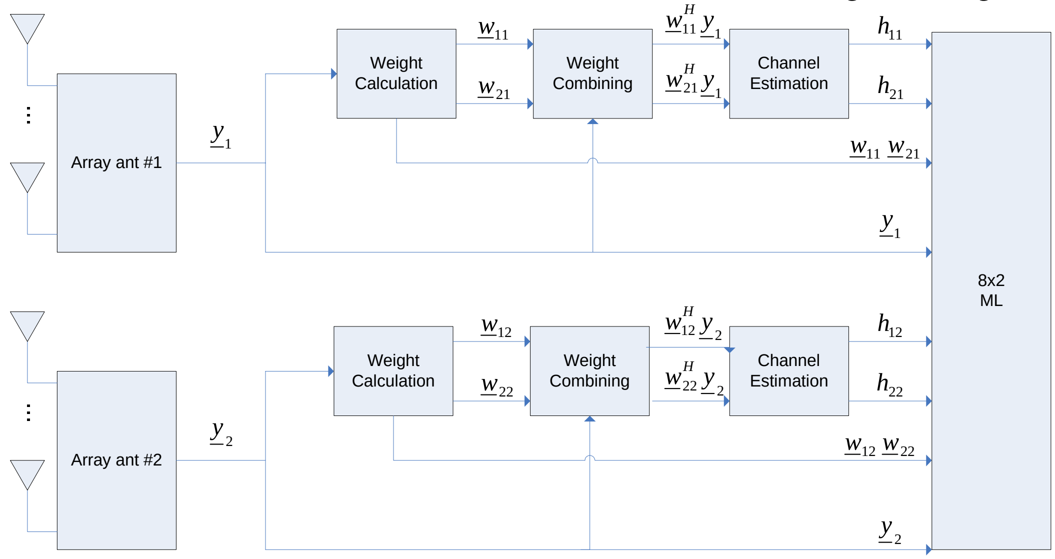

Figure 3 Block Diagram of Proposed Algorithm

- FFT Size : 1024 FFT
- Channel : Rayleigh Fading
- Mobile Speed : 60km/h
- Channel Estimation : Linear Interpolation
- Channel Coding : Convolutional turbo code (1/2).
- Weight Calculation : Lagrange algorithm
- Number of Tx Antenna : 2
- Number of Rx Antenna : 2 or 8

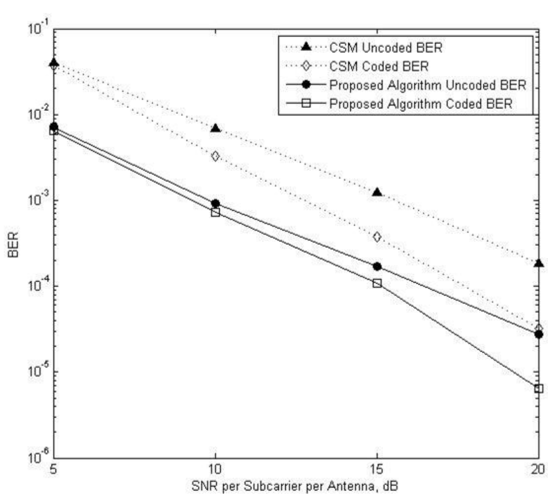

Figure 4 Average BER Performance Comparison

Figure 4 shows the performance comparison of 2x2 CSM and proposed algorithm. In the case of proposed algorithm, we assume that incident angle is -38 degree and 20. Also, it is assumed that steering vectors between base stations are the same since inter-base station distance is small compared to the inter-mobile stations. As shown Figure 4, proposed algorithm is observed that the BER is improved by 6 dB than CSM based on IEEE.802.16e standard, because antenna element of proposed algorithm is increased 4 times more than CSM. It is concluded that weight calculation is almost exactly, so we can get full SNR gain.

6. CONCLUSION

This paper has presented a design and performance analysis of CSM+BF. The goal of this paper is to combine advantage of two multiple antenna scheme. The simulation result shows our proposed algorithms can combine diversity gain of CSM and SNR gain of BF. All of simulation has done based on IEEE 802.16e standard. So proposed algorithms can be used in realistic system.

7. ACKNOWLEDGEMENT

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