ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

**International Journal of Innovative Research in Computer and Communication Engineering**

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijircce.com*

**Vol. 5, Issue 9, September 2017**

# Performance Analysis of MIMO Detection under Imperfect CSI

Pragya Vyas [1] , Shashank Mane[2]

PG Scholar, Department of Electronics and Communication Engineering, Shri Balaji Institute of Technology and Management, Betul (MP) India

Department of Electronics and Communication Engineering, Shri Balaji Institute of Technology and Management, Betul (MP) India

**ABSTRACT** : We consider transmit side correlated multi-input multi-output (MIMO) channels with block fading, where each block is divided into training and data transmission phases. The receiver has a noisy CSI that it obtains through a channel estimation process, while the transmitter has partial CSI in the form of covariance feedback. OFDM exhibits excellent annotation in channel fades and interferers as only a few subcarriers can be affected and consequently a small part of the original data stream can be lost. Orthogonality between frequencies ensures better spectrum management and obviates the danger of intersymbol interference. However, an essential problem exists. In this paper we present two new techniques for reducing Imperfect CSI Based on Bayesian Model, which can be added in any OFDM system

**KEYWORDS**: CSI *OFDM*

## I. INTRODUCTION

Orthogonal Frequency Division Multiplexing (OFDM) has been distinguished between other types of data transmission and reception schemes, for its excellent tolerance towards multipath fading and for supporting even higher data rates. OFDM has been a primary part of interest in many scientific researches and it has been included and implemented in various standards and application fields. Digital Audio Broadcasting (DAB), Terrestrial Digital Video Broadcasting (DVB-T), Wireless Local Area Network (WLAN – IEEE 802.11), High-Performance LAN type 2 (HIPERLAN/2), Broadband Wire- less Access (BWA – IEEE 802.16), Mobile Broadband Wireless Access (802.20), wimax, Broadcast Radio Access Network (BRAN), Digital Subscriber Lines (DSL) and Multimedia Mobile Access Communication (MMAC) have all adopted OFDM [1].

## II. PROBLEM DEFINITION

Many schemes for reducing Imperfect CSI have been proposed and are worth mentioning not only for their innovations but also due to hard work that appears to have been done by all authors. Clipping is very simple and has a quick implementation [2]. Unfortunately it causes out- of-band radiation. Even if digital filtering is used for reducing radiation [3] which is very proper to do, BER deteriorates. Constellation shaping using SLM method in conjunction with Hadamard code [4] offers good results but complexity of this method is relatively high compared to others, like Low Complexity Technique which utilizes simple algorithm [5]. The latest still requires magnifier in receiver. Also in-depth BER performance is not mentioned. But, we must not omit the fact that its Imperfect CSI performance is fine. Another scheme is Imperfect CSI reduction with Huffman Coding [6] but it introduces the necessity of transmitting the encoding table to receiver. Even if bandwidth will not be affected, a serious drawback remains. System complexity is high. Another excellent idea is about recovering the clipped part of the OFDM signal [7], but it has restrictions, like trading-off between low CR and increasing the amount of the copied signal which in turn introduces redundancy in the transmitted data. Using a root commanding transform technique still requires expander in the receiver and exhibits

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

**International Journal of Innovative Research in Computer and Communication Engineering**

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijircce.com*

**Vol. 5, Issue 9, September 2017**

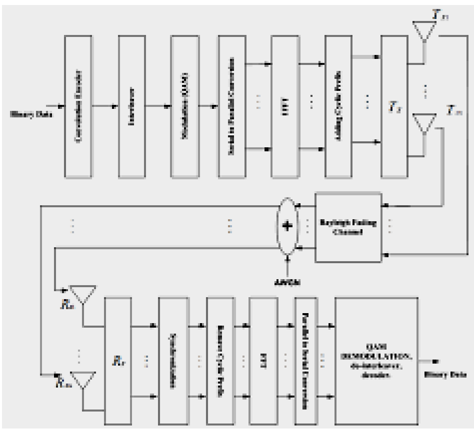
good trade-off between imperfect CSI and SER. SER Performance appears to be good but not innovative. Other technique using combined interleaving and commanding [6][7] exhibits good CCDF performance but introduces the necessity of k interleaves in transmitter's part. Also side information must be sent to receiver containing identities of corresponding interleavers. This deteriorates simplicity of system design.

## III. PROBLEM ANALYSIS

The review first part of our work involved with the study of selected companders and was focused especially in two already known schemes which are soft reduction and µ-algorithm. We selected these as they are simple techniques compared to others. We didn't use the expanded parts of these algorithms in the receiver in order to avoid overall complexity. Then we conducted various simulations ending up in finding two new strong candidates for Imperfect CSI reduction without deteriorating BER system performance. In the third part of our study final simulations of an OFDM system (with IFFT subcarriers) were conducted.

## IV. OBJECTIVES

Our platform which is used as a basic simulation testbed, forms an OFDM system. All system delays were computed in order to apply a perfect synchronization between transmitter and receiver. Also, each time we added or removed blocks we calculated the power characteristics of the new generated OFDM signal, in order our simulations to produce the highest possible accurate results. Transmitter system under test was constituted of a random generator, a convolutional encoder, a QPSK modulator, a serial to parallel converter, an oversampling procedure using double zero padding, an IFFT block, a cyclic prefix generator and an unbuffering procedure. All inverse computations were implemented in receiver's part. Specifically for implementing convolutional encoder we used a design with one input, six shift registers and two adders complying with industry standard rate of 1/2 [1]. The review simulation system that we developed is proposed to produce to from 64 to 8192 subcarriers in IFFT output. Table characteristics of up to 4096 subcarriers system were used from our previous study on noise effects in large number of subcarriers [2][3]. Simulation testbded of 8192 subcarriers in IFFT output was conformed accordingly to table structure of previous paper. Our system design appears in Figure 1.




## V. DESIGN ANALYSIS

The proposed scheme $\mu$-Law Soft Reduction – $\mu$lsr introduces the attachment of a new compressor after Cyclic Prefix function[4][5]. Companded output can be represented by following equations without the need of expanding it in receiver's part. By using Soft Reduction (SR) in the output of Cyclic Prefix, signal peaks which exhibited larger values than others in relation to threshold, were attenuated in a greater extend [6]. Imperfect CSI decreased along with the peak-to- peak amplitude of the *CP*. In our simulations we didn't implement the previous block in order to keep low complexity in system design.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

**International Journal of Innovative Research in Computer and Communication Engineering**

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijircce.com*

**Vol. 5, Issue 9, September 2017**

## VI. METHODOLOGY

Most of the studies assume a rich scattering environment such that the spatial subchannels can be modeled as independent and identically distributed (i.i.d.) frequency flat Rayleigh fading channels. In practice, the fading processes are usually space-, time-, and frequencyselective. A channel model including all these selective fading effects is referred to as triply selective [1]. Furthermore, channel state information (CSI) is often obtained by using periodically inserted pilot symbols and the resulting estimate is never perfect. The CSI estimation error can significantly degrade a MIMO receiver's performance even if a maximum likelihood (ML) detector is in place. As a result, more recent MIMO system investigations have considered more realistic channel conditions and taken into account imperfect CSI at both transmit and receive sides. Efforts to enhance MIMO system robustness against imperfect CSI come from two main fronts: 1) those using space-time coding or channel coding and 2) those proposing improved sub-optimum detectors. Among the former, it is worth citing [2], where a space-time trellis coded optimum receiver for Rayleigh fading was proposed.

In this section we will describe a MIMO channel model that captures the above characteristics and that can be collapsed to an underlying SISO ITU channel model. We will first start by describing a basic underlying model for a SISO link and then generalize this model in an incremental fashion to describe MIMO channels. A simple model for a SISO link is given by

$$h(t) = \sum_{i=1}^{K} \alpha_i(t) \cdot \delta(t - \tau_i) \qquad 1$$

where $\alpha_i(t)$ is the complex tap gain which is assumed to be a complex Gaussian random variable with zero mean and variance $\sigma_i^2$, $\tau_i$ is the corresponding delay, and $K$ is the number of taps in the channel profile. Note that in this model we assume that the time delays $\tau_i$ changes very slowly with time such that we can assume that they are constant. Also, the tap gains are time varying in general. The tap gains will have an autocorrelation function $R_\alpha(\nu)$ that will depend on the scattering process as well as the mobility of the transmitter and/or the receiver. In the case of uniform scattering, this will be the classical Jakes spectrum model with $R_\alpha(\nu) = J_o(2\pi f_d \nu)$ where $f_d$ is the maximum delay spread of the channel. Note that we also that complex tap gains are independent.

Now in order to generate an equivalent digital channel model, the transmit and receive filtering of the channel needs to be taken into consideration as follows. Let $g(t)$ be the transmit pulse shape and $f(t)$ be the receive filter impulse response. Let us also assume that the transmitted signal from some transmitter in the network is

$$s(t) = \sum_n s_n g(t - nT_s) \qquad 2$$

where $s_n$ is the digital symbol being transmitted and $T_s$ is the symbol period. The corresponding received signal is

$$r(t) = s(t) * h(t) * f(t) = x(t) * h(t) \qquad 3$$

where

$$x(t) = s(t) * f(t) = \sum_n s_n \tilde{g}(t - nT_s) \qquad 4$$

is the overall transmitted signal that includes the effects of pulse shaping, transmit filtering, and received filtering and $\tilde{g}(t) = g(t) * f(t)$. Hence, the received signal can be rewritten as

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

# International Journal of Innovative Research in Computer and Communication Engineering

*(An ISO 3297: 2007 Certified Organization)*

*Website: www.ijircce.com*

Vol. 5, Issue 9, September 2017

$$\begin{aligned} r(t) &= h(t) * x(t) \\ &= \left\{ \sum_{i=1}^{K} \alpha_i \cdot \delta(t-\tau_i) \right\} * \left\{ \sum_n s_n \tilde{g}(t-nT_s) \right\} \\ &\approx \sum_n s_n \sum_{i=1}^{K} \alpha_i \int_\beta \delta(\beta-\tau_i)\tilde{g}(t-\beta-nT_s)d\beta \\ &= \sum_n s_n \sum_{i=1}^{K} \alpha_i \tilde{g}(t-\tau_i-nT_s) \end{aligned} \quad 5$$

Note that in the above equation, we assumed that the tap gains $\alpha_i$ will remain constant over a symbol period. Let us now assume that the received signal is over sampled by a factor of $Q$ at the receiver, i.e. the sampling instants are

$$t = kT_s + \frac{qT_s}{Q} \qquad k = 0,1,2,\dots \quad , \quad q = 0,1,2,\cdots,Q-1 \quad 6$$

Then we will have

$$r\left(kT_s + \frac{qT_s}{Q}\right) = \sum_n s_n \sum_{i=1}^{K} \alpha_i \cdot \tilde{g}\left((k-n)T_s + \frac{qT_s}{Q} - \tau_i\right) \quad 7$$

Let $k-n=m$. Also, a reasonable assumption to make here is that the overall channel response (including pulse shaping and transmit and receive filtering) will have a finite duration. Hence, we will have

$$\begin{aligned} r\left(kT_s + \frac{qT_s}{Q}\right) &= \sum_{m=0}^{L} s_{k-m} \sum_{i=1}^{K} \alpha_i \cdot \tilde{g}\left(mT_s + \frac{qT_s}{Q} - \tau_i\right) \\ &= \sum_{m=0}^{L} s_{k-m} \cdot h_m(q) \end{aligned} \quad 8$$

where

$$h_m(q) = \sum_{i=1}^{K} \alpha_i \cdot \tilde{g}\left(mT_s + \frac{qT_s}{Q} - \tau_i\right) \quad 9$$

is the equivalent digital channel tap. Let us consider the symbol rate equivalent channel (i.e. $q=0$, the case when the output of the receive filter is sampled at the symbol rate):

$$\begin{bmatrix} h_0(0) \\ h_1(0) \\ h_2(0) \\ \vdots \\ h_L(0) \end{bmatrix} = \begin{bmatrix} \tilde{g}(-\tau_1) & \tilde{g}(-\tau_2) & \tilde{g}(-\tau_3) & \cdots & \tilde{g}(-\tau_K) \\ \tilde{g}(T-\tau_1) & \tilde{g}(T-\tau_2) & \tilde{g}(T-\tau_3) & \cdots & \tilde{g}(T-\tau_K) \\ \tilde{g}(2T-\tau_1) & \tilde{g}(2T-\tau_2) & \tilde{g}(2T-\tau_3) & \cdots & \tilde{g}(2T-\tau_K) \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ \tilde{g}(LT-\tau_1) & \tilde{g}(LT-\tau_2) & \tilde{g}(LT-\tau_3) & \cdots & \tilde{g}(LT-\tau_K) \end{bmatrix} \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \vdots \\ \alpha_K \end{bmatrix} \quad 10$$

or in a vector form

$$\mathbf{h}(t) = \tilde{\mathbf{G}}(\boldsymbol{\tau}) \cdot \boldsymbol{\alpha}(t) \quad 11$$

The model in (10) and (11) describes a SISO ISI channel. The time correlation behavior of the channel is reflected in the time correlation behavior (which depends on the Doppler spread of the channel) of the tap gains $\alpha_i$'s. The

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 9, September 2017

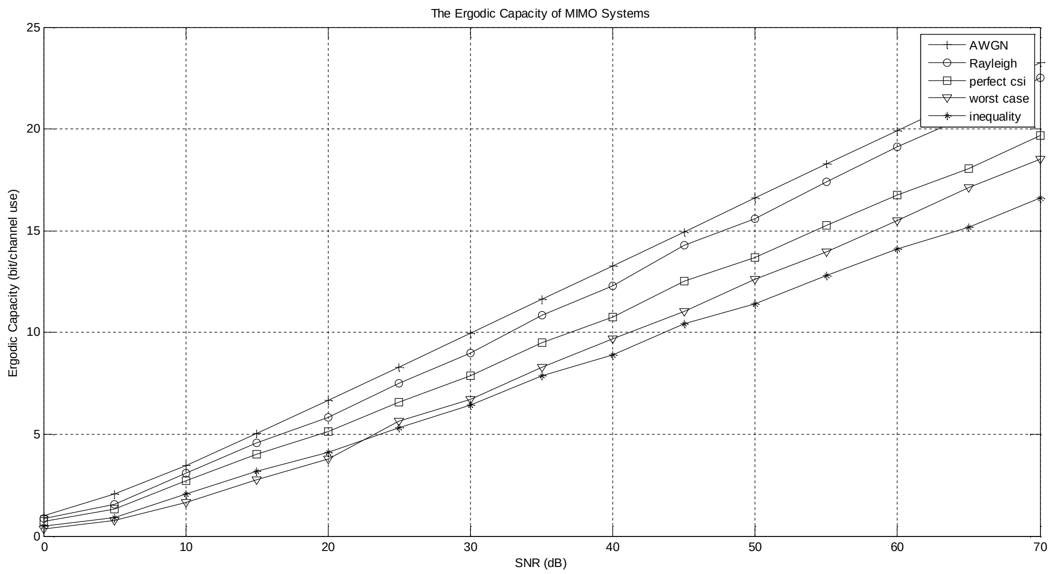
frequency correlation behavior of the channel is reflected in the pulse shaping matrix $\tilde{\mathbf{G}}(\boldsymbol{\tau})$ and its dependency on the time delays $\tau_i$'s (and hence its dependency on the channel delay spread).
A MIMO channel with $N$ transmit and $M$ receive antennas is made up of $N \times M$ SISO links with $K$ multipth components. The channel coefficients for one of $K$ multi-path components are given by a $M \times N$ complex matrix. We denote the channel matrix for the ***i***-th multi-path component as $\mathbf{A}_i(t)$, where $i = 1,\ldots,K$. The broadband MIMO radio channel transfer matrix $\mathbf{H}(t)$ can be modeled as

$$\mathbf{H}(t) = \sum_{i=1}^{K} \mathbf{A}_i(t)\delta(t-\tau_i) \qquad 12$$

where $\mathbf{A}_i(t) \in C^{M\times N}$ and

$$\mathbf{A}_i(t) = \begin{pmatrix} \alpha_{11}^{(i)}(t) & \ldots & \alpha_{1N}^{(n)}(t) \\ \vdots & \ddots & \vdots \\ \alpha_{M1}^{(i)}(t) & \cdots & \alpha_{MN}^{(i)}(t) \end{pmatrix} \qquad 13$$

We follow the format specified by the LTE standard [6] and propose model selection schemes to guarantee robustness.The proposed selection scheme offers an approximately 7 dB gain with respect to the worst-case scenario at BER = 10-3 when nw = 1. Increasing nw to 4 and using (9), we obtain an additional 3 dB gain at BER = 10-4. In Fig. 2, we plot the successful rate performance as a function of Eb/N0 for different observation window sizes when the true channel is M2. In this case, the successful rate is defined as the average ratio of correctly identifying the true model number. As expected, the successful rate is a monotonically increasing function of Eb/N0 since the approximation (6) becomes more and more accurate as Eb/N0 increases. This figure also indicates that by increasing nw, we can improve the performance, especially at low and medium Eb/N0 values.



ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Website: www.ijircce.com

Vol. 5, Issue 9, September 2017

## VII. CONCLUSION AND FUTURE SCOPE

In this paper we proposed two new techniques for decreasing Imperfect CSI. The primary concern was to accomplish this with no BER deterioration and hence to keep complexity of the system as low as possible. BER curves for $\mu$lsr and $\mu$lacp which were derived from simulations (in the absence of ADC and DAC) showed clearly not a severe deterioration. $\mu$lsr had a slightly better performance (0.5 db) compared to $\mu$lacp, but the last exhibited a superior Imperfect CSI performance in terms of probability and maximum Imperfect CSI . Both techniques don't include an expander in receiver's part, for simplicity reasons. This is also a future goal of us, along with the design of a final OFDM system (vast number of subcarriers) introducing precise channel estimation. Reduced, which could result in higher-speed with reference to dynamic scaled data transfer.

## REFERENCES

[1] B. Das , S. Tiwari, S. Das, "Performance Study of Discrete Wavelet Packet Based MB-OFDM System for Short Range Indoor Wireless Environment", International Journal of Devices and Communications (icdecom) , Feb. 2011.

[2] Le Chung Tran and Alfred Mertins, "Space-Time-Frequency Code Implementation in MB-OFDM UWB Communications: Design Criteria and Performance", International Journal of WIRELESS COMMUNICATIONS, Feb. 2009.

[3] Tiejun (Ronald) Wang, John G. Proakis, James R. Zeidler, "Techniques for Suppression of Intercarrier Interference in OFDM Systems", International Journal of Wireless Communications and Networking, 2005.

[4] Ahmad Gomaa, Naofal Al-Dhahir, "A Sparsity-Aware Approach for NBI Estimation in MIMO-OFDM", International Journal of WIRELESS COMMUNICATIONS, 2011.

[5] Ming Jiang, Lajos Hanzo, "Multiuser MIMO-OFDM for Next-Generation Wireless Systems" , Proceedings of the IEEE , July 2007.

[6] Raghuveer M. Rao, "Wavelet Transforms Introduction to Theory and Applications" , Pearson Fifth Impression , pp 135, 2011.

[7] Theodore S. Rappaport, "Wireless Communications Principles and Practice" , Pearson Fourth Impression , pp 329, 2011.