International Journal of Control Theory and Applications

ISSN : 0974-5572

Volume 10 • Number 28 • 2017

Performance Analysis of Link Adaptive Modulation Schemes for MIMO-OFDM

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Abstract: Link Adaptation Schemes adapts the transmission parameters to the channel varying in time to improve the spectral efficiency of channel. In addition, these adaptive systems provide adequate gain in performance, less complexity and reduced feedback overhead. The paper examines the purposed scheme's performances which adapts the high SNR value for modulation schemes of higher-order with high spectral efficiency and suitable code rate is choosen depend on the quality of the channel. In case of low value of SNR, the algorithm moves to a modulation scheme of lower-order, which has a lower spectral efficiency but it is more robust against the errors.

Index Terms: Multiple Input Multiple Output, Othogonal frequency Division Multiplexing, Link Adaption Schemes, Channel Estimation.

1. INTRODUCTION

Nowadays Multiple Antenna Communication is the main focus in research of the wireless communication. MIMO Technology is used to increase the capacity of the system. The effects of Interference and Fading can be combated to increase the link capacity. MIMO system make use of number of Transmitter and Receiver antennas which exploits the multipath propagation in environment of rich scattering. MIMO can be regarded as a solution to increase spectral efficiency without adding bandwidth or transmission power. OFDM for the MIMO channels (MIMO-OFDM) is taken in consider for transmission to lower the inter-symbol interference and adds the system capacity[13].

The 4G and 5G wireless communication systems guarantees high data rates with low complexity and reliable communications over limited bandwidth. OFDM is a powerful technique for a high data rate wireless communication. OFDM transform the frequency selective channel into a big set of the individual frequency narrowband nonselective channels, which is suits for structure of MIMO that requires a characteristic of frequency non-selective at each channel when the rate of transmission is high enough to make the whole channel frequency selective. Therefore, a MIMO system employing OFDM, denoted MIMO-OFDM, is able to achieve high spectral efficiency. However, the adoption of multiple elements of antenna at the transmitter for spatial transmission results in a superposition of several transmitted signals at the receiver weighted by multipath channels corresponding to that and makes the reception more difficult. This imposes a real challenge on how to design a system practically that can offer improvement in spectral efficiency. Especially the MIMO combined with OFDM have been used as primary techniques in the 4G communication systems. MIMO-OFDM is the base for number of mobile broadband network and advanced wireless LAN's standards because it achieves the higher spectral efficiency and, therefore, it gives the higher capacity and better data throughput in various wireless applications[8][9].

Link level adaptive mechanism of MIMO-OFDM can adjust the modulation scheme and data rate based on CSI to rise the system bandwidth efficiency. Several authors in literature [2-4], have proposed the analytical study of the performance of MIMO OFDM adaptive systems. As the number of bits in the modulated symbol is increased, it increases the data rate using higher modulation scheme under the suited channel conditions. Among number of strategies, the technique of Adaptive Modulation has been taken to provide an best non line of sight coverage. Technique of Adaptive modulation allow the system to adapts to the modulation scheme accordance to the conditions of channel in order to increase the performance of the system.

In this paper we first introduce the model of MIMO-OFDM, with channel estimation block in Section-II. Then in Section-III, the results are shown and discussed. Then in Section-IV the Link adaption is described in general and afterward in Section-V, the Channel estimation is described. Then at last, in Section-VI, paper is concluded.

2. SYSTEM MODEL

The Figure 1 gives the system model which represents the link-level of the communication system (wireless). The transmitter selects one of the QAM or QPSK level to modulate the data, and then data is interleaved. An inverse FFT generates the OFDM time signal. Cyclic Prefix is used as a Guard time for the time signal of OFDM to avoid the Inter Symbol Interference and is then transmitted over the number of transmit antennas (Nt) under the Rayleigh fading channel.

At the receiving side, the multipath signals received are combined with the use of diversity technique maximal ratio combining (MRC) to get the maximum ratio of SNR and then sent it to serial to parallel block. The FFT block transforms the signal in time domain gain in to the frequency domain, which is demodulated coherently. The channel estimation is supposed to be perfect at the receiver [7]. Then the terminal communicates the SNR in the CSI format via the feedback channel to the transmitter.

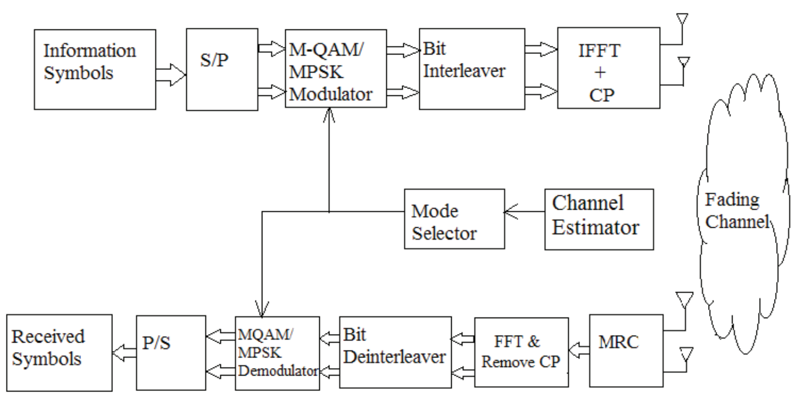


Figure 1: MIMO-OFDM System Model [11]

Consider 2 M-QAM levels,i.e.16-QAM and QPSK, and at the transmitter average SNR is 10dB. The fading channel coefficients of Rayleigh are generated for each spatial link independently [5]. This link-level approach a point-to-point MIMO link. Assume that the channel is quasi-static. In non-line of sight scenarios, the wireless channel behavior is described by Rayleigh fading model. The channel coefficients, h, follow N $(0, \sigma_h^2)$. The SNR of the link relates to the transmit power and noise as $\gamma = h^2$ and the PDF of the SNR is given by eq.1:

$$f(\gamma) = \frac{1}{\sigma_h^2} \exp\left(-\frac{\gamma}{\sigma_h^2}\right)$$

The diversity technique of Maximal Ratio Combining (MRC) maximizes SNR value from the i.i.d. fading channels, by the symbols weight age at each antenna with the channel coefficient conjugate [6].The number of transmit antennas (N_t) encoded the signal. The total power at the transmitter is divided equally among the N_t transmission antennas. The received signals N_r are also combined with the MRC, using the channel knowledge which is estimated at the receiver. The resulting γ and its PDF are then given by the eq.2:

$$\gamma = \frac{1}{N_t} \sum_{p=1}^{N_r} \sum_{q=1}^{N_t} \left| h_{p,q} \right|^2$$

and, PDF of SNR will be given by eq.3:-

$$f(\gamma) = \left[\frac{N_t}{\sigma_h^2}\right]^{N_t N_r} \frac{\gamma^{N_t N_{r-1}}}{(N_t N_r - 1)!} \exp - \left[\frac{N_t \gamma}{\sigma_h^2}\right]$$

3. LINK ADAPTION IN MIMO-OFDM SYSTEM

When at both link ends the CSI is known then it is possible to obtain independent sub-channels. However, with the channel coefficient knowledge, we can dynamically adapt the transmission parameters (i.e., power transmitted for each sub-channel) and modulation. The result would be that there is significant improvement in the performance of system[1]. Depending upon requirements may be it throughput maximizing of the system at a certain BER or minimizing the BER overall, while the data rate remain unchanged, the transmission parameters can be adjusted optomally to meet these goals.

4. CHANNEL ESTIMATION

In a wireless communication link, the information of channel state provides the channel properties of the link. This CSI should estimated at receiver and generally fedback to transmitter. Therefore, the receiver and transmitter have different CSI. The information of Channel State might be or statistical or instantaneous. In the instantaneous CSI, the present channel condition are known, which could be viewed by knowing the impulse response of sequence transmitted. But Statistical CSI contains the individualities that are statistical such as spatial correlation, channel gain, fading distribution, etc. The acquisition of CSI is limited practically by how quickly the condition of channel are changing.

In system of fast fading, where conditions of channel rapidly varies under the transmission of the symbol information, only statistical CSI is reasonable. But, in systems with slow fading, instantaneous CSI can be estimated with suitable accuracy. So technique of channel estimation is mainly introduced to improve the accuracy of the received signal. In mobile communication systems, the radio channel are usually the multipath fading channels, which are causes the inter symbol interference (ISI) in the signal received. To remove ISI from the received signal, at the receiver side different kinds of detection algorithms are used. These detectors may have the channel impulse response (CIR) knowledge, which can be provided by separate channel estimator.

Channel estimation algorithm basic classifications are training based, semiblind channel estimation or the blind channel estimation. The channel estimation of training based may be performed by either the comb type or block type pilots. Pilot tones are inserted into all bins of frequency in the estimation of block type with the periodic interval of the OFDM blocks. This type of estimation is best for slow fading channels whether the Comb-type channel estimation is appropriate where there is change even in the one block of OFDM. The estimation of blind channel is carried out by evaluate the information of channel and particular properties of the signals that are transmitted[10].

5. RESULTS & DISCUSSIONS

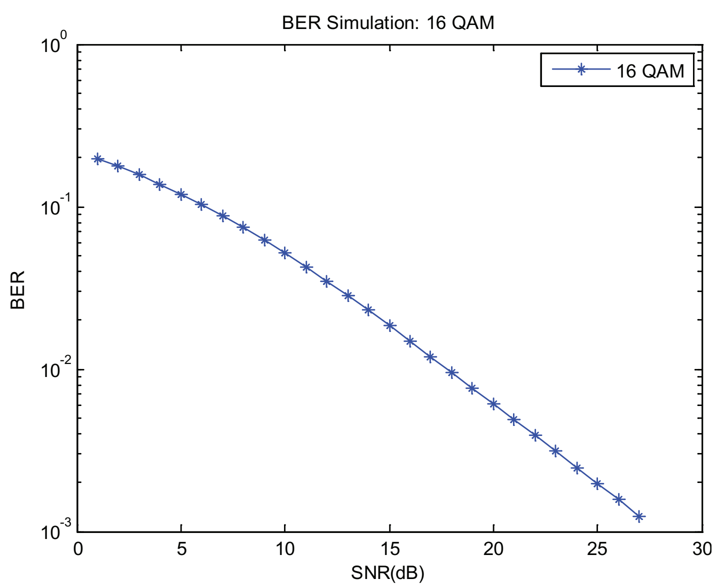
In Table 1 the simulation parameters are listed which gives that system is operating at a sampling rate of 20MHz. It uses 32-point FFT and 52 are Data-subcarriers. The OFDM symbol duration having a Cyclic Prefix of 2. The modulation schemes (16-QAM,64-QAM and 256-QAM) are used and the Rayleigh channel is selected.

Table 1
Simulation Parameters

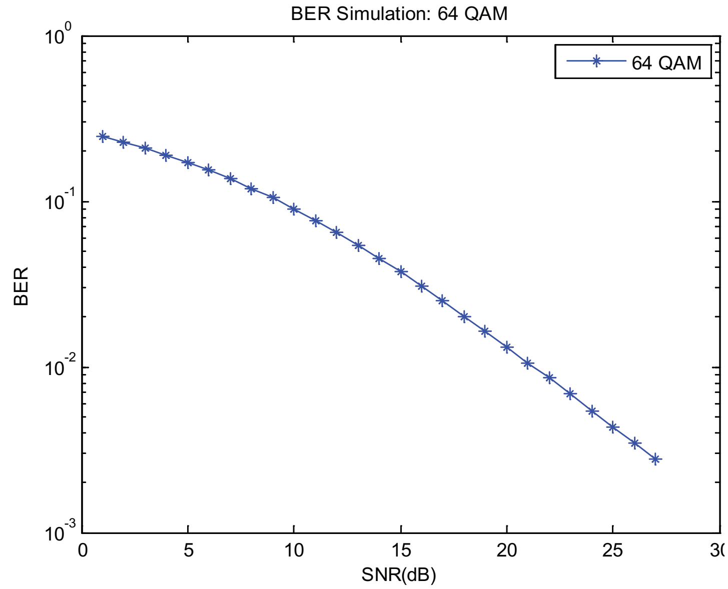
Parameter	*Value*
Sampling rate frequency	20 MHz
IFFT size	32
Number of Data Subcarriers	52
No. of input serial bits	10^4 bits
FFT symbol period	3.2 μs
Modulation scheme	16QAM,64QAM and 256-QAM
Channel	Rayleigh

Result Analysis

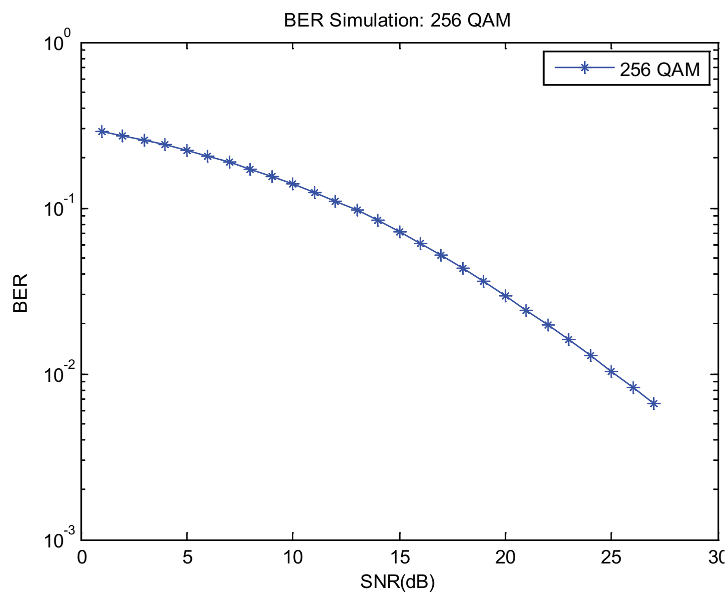
Figure 2 gives the simulation results that shows the BER performance of the adaptive M-QAM modulation schemes.



(a) 16-QAM



(b) 64-QAM



(c) 256-QAM

Figure 2: BER of a M-QAM adaptive system (a) 16-QAM (b) 64-QAM (c) 256-QAM

These results shows that M-QAM modulation is able to meet the target BER. At an operating BER, there is no such modulation scheme that gives the desired performance at an SNR value below 15 dB. And at higher value of SNR (>30dB), 256-QAM technique while providing the desired BER performance, it provides the good efficiency. Furthermore in the case of low value of SNR(<30), the algorithm moves to a lower-order modulation scheme(16-QAM).

6. CONCLUSION

In this paper we concluded that the performances of the scheme proposed, which adapts the high SNR value for higher-order modulation schemes with high spectral efficiency and appropriate code rate can be chosen depending on the channel quality. In the case of low SNR, the algorithm turns towards to a lower-order modulation scheme, which is more robust against transmission errors but it has a spectral efficiency lower.

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