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Capacity of Various Digital Modulation Techniques using MIMO-OFDM System

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ABSTRACT

The High data rate wireless systems with very small symbol periods usually face unacceptable Inter-Symbol Interference (ISI) originated from multipath propagation and their inherent delay spread. Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier-based technique for mitigating ISI to improve capacity in the wireless system with spectral efficiency (bps/Hz). On the other hand, Multiple-Input Multiple-Output (MIMO) systems have rising attention of the wireless academic community and industry because their promise to increase capacity and performance with acceptable BER proportionally with the number of antennas [1].

Keywords :- : OFDM, MIMO, ISI,BER,CAPACITY.

I. INTRODUCTION

For high data rate wireless communications, Orthogonal Frequency Division Multiplexing (OFDM) is one of the most promising technologies due to its high spectral efficiency, robustness, frequency selective fading and low computational complexity. OFDM can be used with Multi Input Multi Output (MIMO) transceiver to increase the diversity gain and the system capacity by exploiting spatial domain. MIMO-OFDM is considered a key technology in emerging high-data rate systems such as 4G because the OFDM system effectively provides numerous parallel narrowband channels [5].

MIMO communication uses multiple antennas at both the transmitter and receiver to exploit the spatial domain for spatial multiplexing and spatial diversity. In this paper MIMO OFDM is analyzed for Rayleigh channel and each sub-carrier being modulated with different digital modulation scheme (such as M –QAM and QPSK) at a low symbol rate, maintaining total data rates similar to conventional single-carrier modulation schemes in the same bandwidth. The primary advantage of OFDM over single-carrier schemes is its ability to cope with severe channel conditions. The low symbol rate makes the use of a guard period between symbols affordable, making it possible to eliminate inter-symbol interference (ISI).

The analysis and simulation of the MIMO OFDM system to reduce ISI and frequency selective fading is considered in two stages. The first stage involves the implementation of a system architecture model with vertical encoding, OFDM modulation demodulation, The second stage compares the SNR performance of the system for various digital modulation techniques by varying transmitting power [6].

II. SYSTEM ARCHITECTURE

A. Orthogonal Frequency Division Multiplexing System

In order to solve the bandwidth efficiency problem, Orthogonal Frequency Division Multiplexing (OFDM) was proposed, which employs orthogonal carriers to modulate the signals. The carriers are spaced at frequency intervals equal to the symbol rate and are capable of separation at the receiver. This carrier spacing provides optimum spectral efficiency.

One of the main problems with this powerful technique has been the need for numerous oscillators at the transmitter and receiver. An elegant solution to this was found in the Fast-Fourier Transform (FFT). By simply performing an FFT on a signal, we can use a single oscillator at the transmitter and receiver. The main idea is that by passing a signal through an IFFT, we multiply each input by $e^{j2pnm/B}$, which is a sampled version of $e^{j2pnm/B}$. This corresponds to a frequency shift of *m/B*. While in the implementation without the FFT, we would need *L* modulators each having a distinct carrier frequency, *fi*, with the FFT we can simply have one modulator at the carrier frequency, while each of the symbols placed into the IFFT will be offset by *m/B* in frequency. The output of the IFFT will be time-domain OFDM symbols corresponding to the input symbols in the frequency-domain. The *cyclic extension* (also called guard interval or zero padding) is added to an OFDM symbol in order to combat the effect of multipath. ISI is avoided between adjacent OFDM symbols by introducing a guard period in which the multipath components of the desired signal are allowed to die out, after which the next OFDM symbol is transmitted. A useful technique to help reduce the complexity of the receiver is to introduce a guard symbol during the guard period. Specifically, this guard symbol is chosen to be a prefix extension to each block. The reason for this is to convert the linear convolution of the signal and channel to a circular convolution and thereby causing the FFT of the circularly convolved signal and channel to simply be the product of their respective FFT's. However, in order for this technique to work, the guard interval should be greater than the channel delay spread. Thus, we see that the relative length of the cyclic extension depends on the ratio of the channel delay spread to the OFDM symbol duration [5].

B. Multiple-Input Multiple-Output System Model

We consider a MIMO wireless communication system employing *M* transmit and *N* receive antennas; hence, the corresponding MIMO wireless communication channel is constituted by (N* M) propagation links.

In OFDM, entire Channel is divided into a number of sub-channels, which are spaced orthogonally to each other such that no ISI is present at the sub- carrier frequency subject to perfect sampling and carrier synchronization. When we sampled at the Sub-carrier frequency of fNC, the channel model becomes

$$Y_{NC} = HNC\, X_{NC+} V_{NC} \; {}_{\ldots\ldots,} \; NC = -f_C/2, \ldots\ldots\ldots f_C/2 - 1.$$

Where f_C is number of sub carrier. If f_C is sufficiently large, the sub channel at each of this sub carrier considers flat fading. Using OFDM, the MIMO detection over frequency selective channels is transformed into MIMO detection over f_C Narrowband flat fading channels.. We assume that channel matrix H is to be known for receiver only.

Theoretical analysis predicts that substantial capacity gains are achievable in communication systems employing MIMO architectures. Specifically, if the fading processes corresponding to different transmit–receive antenna pairs may be assumed to be independently Rayleigh distributed.

III System Model

The system works in an indoor environment. The proposed system is a single-TDMA stream scheme capable to handle rates ranging adaptively from 64 kbps to 100 Mbps after variable-rate adaptive modulation is implemented, according to the sub-carrier SNR and target BER.

The MIMO OFDM system operates in the 17 GHz unlicensed frequency band with an available bandwidth of 200 MHz (17.1–17.3 GHz) that is divided into four 50 MHz-width channels not simultaneously selectable. OFDM with $L = 128$ sub-carriers (frequency sub channels) is designed for each of these 50 MHz wide channels. The indoor coverage ranges from 5m for non line-of-sight to 20 m for line-of sight (LOS).

A. Transmitter

In figure I the transmitter have an array of antennas and perform a MIMO vertical encoding (VE). At transmitter encode the bit stream from the information source. Then according to the type of modulation technique, coded bits are mapped to some symbols.

The symbol frame is passed through a one to four demultiplexer (1:4), which maps symbols on the *4* space channels (sub-streams of the original frame). Each symbol sub-stream is then put through a serial-to-parallel (S/P) converter which produces 512 parallel output symbols corresponding to the OFDM sub-band channels. These channels modulated by different sub carriers. These symbols are put through the IFFT and 512 parallel output symbols convert into serial sub-stream and then transmitted by the antenna n ($n = 1, 2,…, 4$).

Because each input to IFFT corresponds to a OFDM sub-carrier, at the output we get a time-domain OFDM symbol that corresponds to the input symbols in the frequency domain.

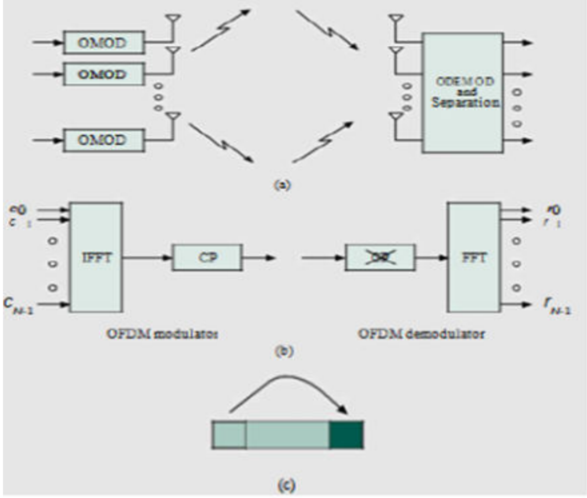

figure I MIMO OFDM V-BLAST Transmitter –Receiver architecture

B. Receiver

Once we received the signal after the channel, first remove the cyclic extension. Then obtain the 512 parallel output symbols corresponding to the OFDM sub-band channels through s/p converter. The FFT is taken in each of the eight(M) receive antennas. Each antenna *m* receives a different noisy superimposition of the faded versions of the *4* transmitted signals. If the transmit and receive antennas are sufficiently spatially separated (at 17 GHz it is about 0.9 cm) and there is a sufficiently rich scattering propagation environment, the transmitted signals arriving at different receive antennas undergo uncorrelated fading. Moreover, if the channel state is perfectly known at the receiver, receiver is able to detect the *N* transmitted sub-streams. The output of the OFDM demodulator, at the receive antenna *m*, is a set of *L(512)* signals, one for each frequency sub-channel. The output of the *L* different signal processors is passed through parallel-to-serial converter and the symbols are demapped and decoded to destination [1].

IV Simulation

Parameters considered in the analysis and simulation of the MIMO OFDM was:

- Total radiated power *Es* independent of *N* (*Es/N* by each Transmitter)
- Flat channel frequency response (delay spread is negligible) in each OFDM sub carrier
- Slow changing channel Complex path gains hi,j is uncorrelated. Correlation in *hij* is also evaluated
- Rich scattering and adequate antenna spacing
- Receiver perfectly knows the channel matrix **H**
- No feedback for estimation of parameters in transmitter is required
- Path delays for all spatial channels are the same and perfect symbol timing synchronization (for sampling) is assumed at the receiver.
- Same multipath-averaged SNR (*Es/ No*) at any receiver branch for a given location
- Comparing results for different number of users.

V. Performance Analysis

We analyzed SNR performance of QPSK, 16 QAM and 64 QAM based on OFDM- MIMO systems with arrays of 4*8 number of transmitter *receiver antenna for different users with same transmitted power. SNR Performance is showed in Figure II and III for 4 user and 8 user respectively. As can be seen, increasing number of user, bit error rate goes down and increase performance. Another interesting note is the fact that for 16-QAM, the BER does not seem to go down very far compare to QPSK, despite a high SNR. This is because for higher order QAM systems, there must be some channel inversion at the receiver to allow for proper decoding.

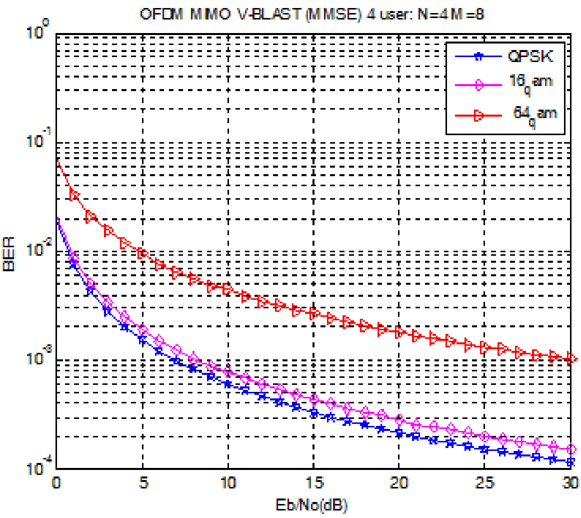

Figure II System Performance Comparison for Various Digital Modulation Techniques for four users.

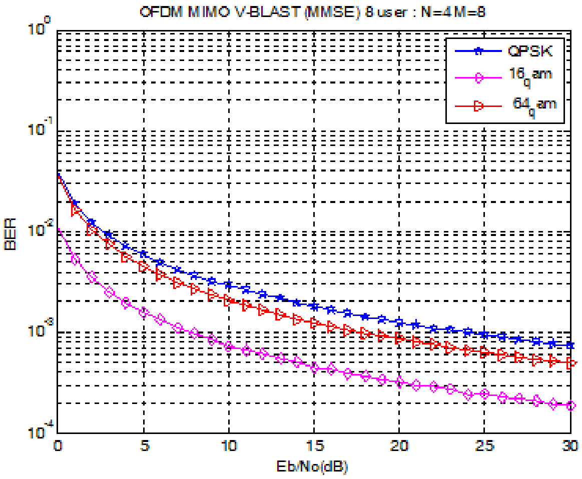

Figure III System Performance Comparison for Various Digital Modulation Techniques for eight users

CONCLUSION

In this paper, we have compare three digital modulation techniques for multiple- antenna systems in frequency-flat, correlated, Rayleighfading channels. The analytical methodology we propose is general and can be used for arbitrary correlation on one side (transmitter or receiver). QPSK based system is having better BER performance compared to 16 - QAM and 64 - QAM system for lower data rates. But since, QPSK system transmits less information than 16 - QAM and 64 - QAM, it is should not be preferred as choice with MIMO OFDM. For 4 users there is best improvement in BER in QPSK MMSE compared to 16 QAM in the range 20dB to 30dB.

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