Implementation of MIMO-OFDM system in Mobile AD-Hoc Networks

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ABSTRACT

Spatial multiplexing is required to configure MIMO antenna. Spatial multiplexing require a high data rate to split into multiple lower data rate stream is transmitted from different transmit antenna in the same frequency channel. If these signals arrive at the receiver antenna array with sufficiently different spatial signature, the receiver can separate these streams, creating parallel channel free. Spatial multiplexing is very powerful technique for increasing channel capacity at higher SNR [1]. The maximum number of spatial stream is limited by lesser number of antennas at the transmitter and receiver. To implement spatial multiplexing in MIMO based Mobile Ad-hoc network we can achieve up to eight times higher data rates compare to selecting only one user pair at a time [2]. To get more data rate we implement MIMO-OFDM scheme for MIMO based Mobile Ad-hoc networks. In this paper we implement a MIMO-OFDM system model for MIMO based mobile ad-hoc network and compare its BER (Bit Error rate) with different modulation technique. The input serial binary data will be

Keywords: ***ad hoc networks, , Multi Input Multi Output (MIMO), Spatial Multiplexing, OFDM, Bit Error Rate.***

1. INTRODUCTION

OFDM is a modulation Technique as well as multiplexing technique as it is divide a single high data rate stream into a number of lower rate streams that are data transmitted simultaneous over some narrow sub channel. OFDM is multi-carrier modulation technique for transmission of signals over wireless channels, which converts frequency selective fading channel into a collection of parallel fading sub channels. In time domain sub carriers are orthogonal and over lap in frequency domain which can save some band width rather than

other modulation technique without causing ICI (Inter carrier Interference).OFDM system create high data rate with long symbol duration by combining low data rate multiple carrier that eliminate ISI. In this paper we implement a MIMO-OFDM system.

OFDM reduces equalization complexity by implementing with IFFT at the transmitter and FFT at the receiver, that converts the wideband signal , affected by frequency selective fading into N narrowband flat fading signals. The beneficial since OFDM enables support of more antennas and large band widths since it simplifies equalization dramatically in MIMO system.

Hence, the available bandwidth is utilized very efficiently in OFDM systems without Causing the ICI (inter-carrier interference). By combining multiple low-data-rate sub-Carriers, OFDM systems can provide a composite high-data-rate with a long symbol duration. That helps to eliminate the ISI (inter-symbol interference), which often occurs along with signals of a short symbol duration in a multipath channel.

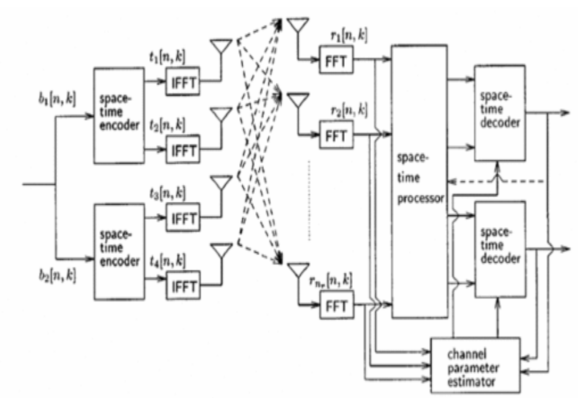
MIMO-OFDM system model processed by a data scrambler and then channel coding is applied to the input data to improve the BER (bit error rate) performance of the system. The encoded data stream is further interleaved to reduce the burst symbol error rate. Dependent on the channel Condition like fading, different base modulation modes such as BPSK (binary phase shift keying), QPSK (quadrature phase shift keying) and QAM are adaptively used to boost the data rate. The modulation mode can be changed even during the transmission of data frames. The resulting complex numbers are grouped into column vectors which have the same number of elements as the FFT size, *N*. For simplicity of presentation and ease of understanding, we choose to use matrix and vector to describe the mathematical model.

OFDM is modulation method is capable to mitigate multipath. In OFDM the high speed data stream is divided into Nc narrowband data streams, Nc corresponding to the sub carriers or sub channels i.e. one OFDM symbol consists of N symbols modulated for example by QAM or PSK. As a result the symbol duration is N times longer than in a single carrier system with the same symbol rate. The symbol duration is made even longer by adding a cyclic prefix to each symbol. As long as the cyclic prefix is longer than the channel delay spread OFDM offers inter-symbol interference (ISI) free transmission. Another key advantage of OFDM is that it dramatically reduces equalization complexity by enabling equalization in the frequency domain. OFDM, implemented with IFFT at the transmitter and FFT at the receiver, converts the wideband signal, affected by frequency selective fading, into N narrowband flat fading signals [1] thus the equalization can be performed in the frequency domain by a scalar division carrier-wise with the sub carrier related channel coefficients. The channel should be known or learned at the receiver. The combination MIMO-OFDM is very natural and beneficial since OFDM enables support of more antennas and larger bandwidths since it simplifies equalization dramatically in MIMO systems. MIMO-OFDM is under intensive investigation by researchers. This paper provides a general overview of this promising transmission technique.

2. MIMO AD HOC NETWORK CHANNEL MODEL

II. System Model

An OFDM system with K sub carriers is considered in this paper, where K is an integer power of two. The relevant model, for the case of coherent transmissions over a time variant channel, is briefly reviewed in the following.



In an OFDM system, at the transmitter part, a high data-rate input bit stream b[n] is converted into N parallel bit streams each with symbol period Ts through a serial-to parallel buffer. When the parallel symbol streams are generated, each stream would be modulated and carried over at different center frequencies. The sub-carriers are spaced by 1/NTs in frequency, thus they are orthogonal over the interval (0, Ts). Then, the N symbols are mapped to bins of an Inverse Fast Fourier Transform (IFFT). These IFFT [11] bins correspond to the orthogonal sub-carriers in the OFDM symbol. Therefore, the OFDM symbol can be expressed as

$$x(n) = (1/k) \sum X(k) \exp\{\frac{j2\pi kn}{K}\},$$

where the *Xm* are the base band symbols on each sub carrier. Then, the *X* (*i*) points are converted into a time domain sequence *x*(*i*) via an IFFT operation and a parallel to serial conversion. The digital-to-analog (D/A) converter then creates an analog time-domain signal which is transmitted through the channel. At the receiver, the signal is converted back to a discrete N point sequence *y*(*n*) , corresponding to each subcarrier. This discrete signal is demodulated using an N-point Fast Fourier Transform (FFT) operation at the receiver. The demodulated symbol stream is given by

$$Y(m) = \sum y(n) \exp\{-j2\}$$

where Y (m) corresponds to the FFT of the samples of y (n), which is the time invariant Additive White Gaussian Noise (AWGN) introduced in the channel Then, the signal is down converted and transformed into a digital sequence after it passes an Analog-to-Digital Converter (ADC). The following step is to pass the remaining TD samples through a parallel-to-serial converter and to compute N-point FFT. The resulting Yi complex points are the complex baseband representation of the N modulated sub carriers. As the broadband channel has been decomposed into N parallel sub channels, each sub channel needs an equalizer (usually a 1-tap equalizer) in order to compensate the gain and phase introduced by the channel at the sub channel's frequency. These blocks are called Frequency Domain Equalizers (FEQ).Therefore the groups of bits that has been placed on the subcarriers at the transmitter are recovered at the receiver as well as the high data-rate sequence.

An OFDM word (or frame) consists of K symbols $\{X(k)\}_{K-1}$ obtained by mapping a sequence of (possibly channel coded and interleaved) bits into a suitable complex-valued constellation, such as phase-shift keying (PSK) or quadrature amplitude modulation (QAM). A subset of the K symbols is typically used as pilot symbols, for use in channel estimation at the receiver side. The symbols X(k) are serial-to-parallel converted and processed by an inverse fast Fourier transform (IFFT) operation, given by:

$$x(n) = (1/k) \sum X(k) \exp\{\frac{j2\pi kn}{K}\},$$

with n€ {0, 1, . . . , K−1}. A cyclic prefix is inserted into the transmitted signal to prevent possible inter symbol interference between successive OFDM frames and to guarantee orthogonality among the subcarriers at the receiver side, in the case of transmissions over linear time-invariant channels. Formally, denoted by L_{CP} , the number of samples in the cyclic prefix (with $L_{CP} \leq K$), the transmitted sequence is obtained by appending the samples $\{X(n)\}$ where n=k- L_{CP} to K-1, at the beginning of the samples $\{X(n)\}$ where n=0 to K-1.

3. CHANNEL ESTIMATION AND DATA DETECTION

In this section, two different approaches for channel estimation and data detection are described. All of them work on the samples at the output of the FFT-based demodulator, which are described by the model in (3). In all cases, before undergoing FFT, the received samples are synchronized in time and frequency.

A. Standard approach

It has been studied that the standard approach for OFDM detection consists of neglecting the ICI and assuming the model in [18] instead of the model in [17]. This assumption, which is exact when the channel is time-invariant and is a good approximation when the channel variations are slow with respect to the duration of the OFDM word [16], reduces the channel estimation to the evaluation of the K complex-valued coefficients $C(k; k)$. Typically, a subset of the sub carriers is reserved for pilot symbols, which are used at the receiver side for channel estimation. Although the optimal placement of the pilot symbols depends on the frequency characteristics of the channel, for simplicity the pilots are usually periodically spaced. Among the various techniques for pilot-based channel estimation, we here consider the technique described in [17], which was successfully adopted in the context of UWA communications to process the data from the AUVfest07 experiment. For all values of k such that $X(k)$ is a pilot symbol, the coefficient $C(k; k)$ is estimated as $C(k; k) = Y(k)/X(k)$. Then, the remaining coefficients are evaluated by linear interpolation. Finally, the estimates are assumed to be correct and standard coherent detection of the information symbols is carried out.

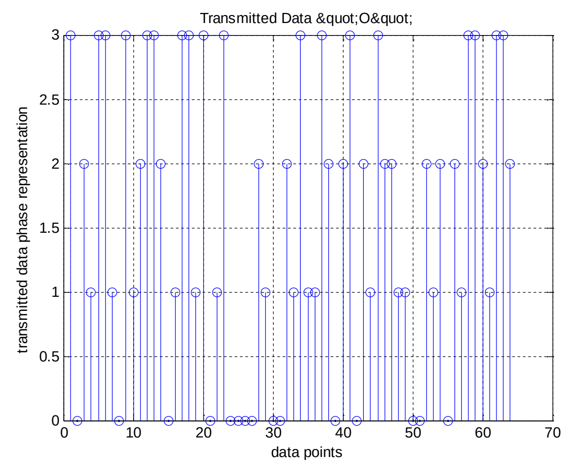
B.ICI CANCELLATION SCHEME

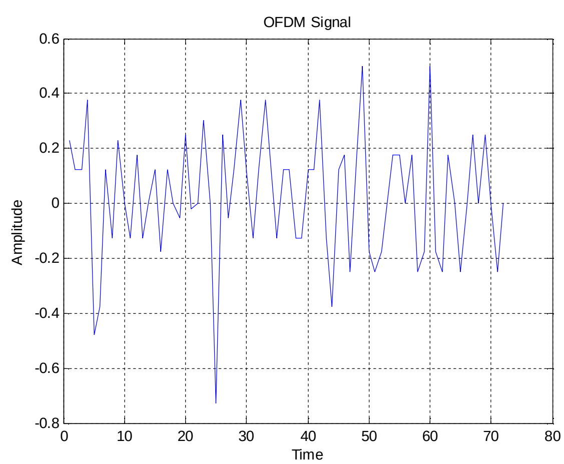
In self cancellation scheme the main idea is to modulate the input data symbol on to a group of sub carriers with predefined self coefficients such that the generated ICI signals within the group cancel each other. The data pair $(X, -X)$ is modulated on to two adjacent sub carriers $(l, l+1)$. The ICI signals generated by the sub carrier l will be cancelled out significantly by the ICI generated by the sub carrier l+1.The signal data redundancy makes it possible to improve the system performance at the receiver side. In considering a further reduction of ICI, the ICI cancellation demodulation scheme is used. In this scheme, signal at the $(k+1)$ sub carrier is multiplied by "−1" and then added to the one at the k sub carrier. Then, the resulting data sequence is used for making symbol decision. By utilizing ICI cancellation scheme it is possible to minimize Bit Error Rate.

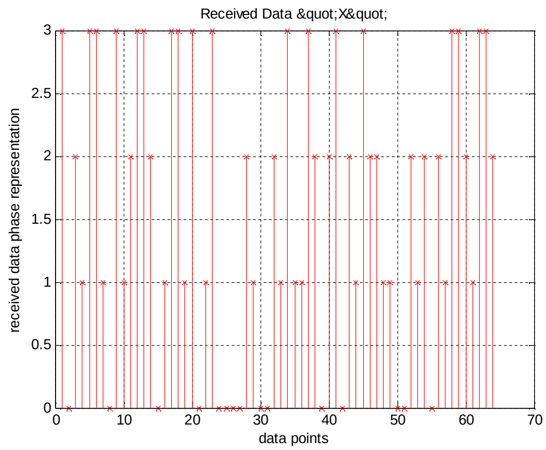
And in the subsequent section we have shown the simulated results.

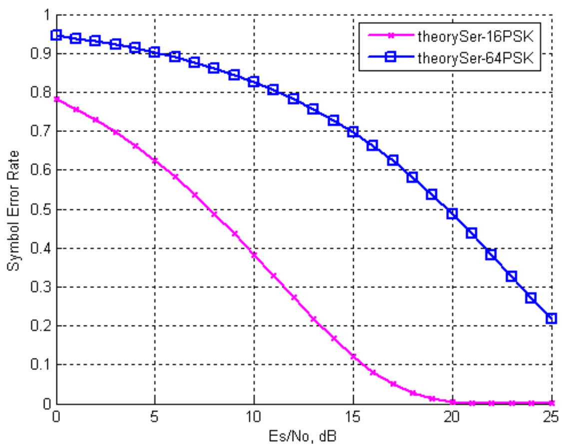
3. SIMULATED RESULT

The fading of a MIMO channel happens due to the scattering of the reflected waves and these are basically the Raleigh and Rican scattering. We have simulated a MIMO-OFDM system model network and graphical presentation of OFDM signal from transmitted data and retrieve receive data from OFDM signal. For calculation of SER we simulate for comparative study of OFDM with 16-PSk, 32-PSK and 16-QAM, 32-QAM. Simulated result shown in figure 2a and 2b.

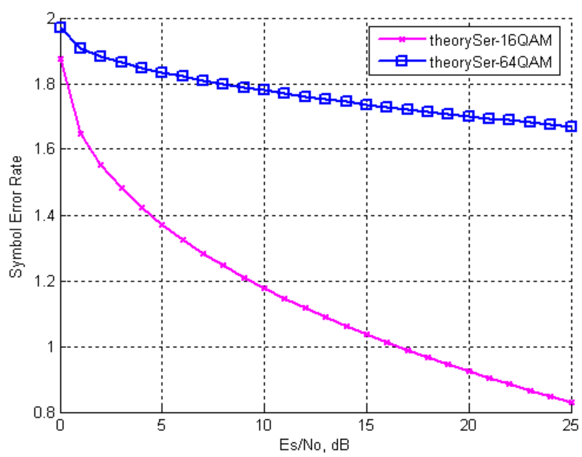








Symbol Error Probability curve for OFDM with 16-PSK and 64-PSK modulation



Symbol Error Probability curve for OFDM with 16-QAM and 64-QAM modulation

4. CONCLUSION

In this paper, we have evaluated the performance of OFDM system using PSK and QAM with OFDM using Generalized Gamma fading distribution. Graphical results show the improvement in OFDM-PSK and QAM system compared to its performance in Gamma fading channel. It is observed that BER is minimum in OFDM-OAM scheme. The reported BER can be further reduced by using channel estimation or suitable diversity scheme.

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