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Analysis of Mimo-OFDM System Using Ultra Wide Band (Uwb) Techniques

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ABSTRACT

Multiple-input multiple-output (MIMO) systems hold the potential to drastically improve the Spectral efficiency and link reliability in future Wireless communications systems. The Multi Input Multi Output (MIMO) Orthogonal Frequency Division Multiplexing (OFDM) based Ultra-Wideband (UWB) systems are set to revolutionize consumer electronics, in the near future. With low power consumption, high data rates up to 480 Mbps, large spatial capacity and low interference with other wireless services due to low power spectral density, MIMO-OFDM based UWB systems are the most sought after for wireless communications. The application targeted by this design was the band 1 of 'Band group 1' based UWB system with a center frequency of 3.432 GHz and a bandwidth of 528 MHz.

INTRODUCTION

OFDM (Orthogonal Frequency Division Multiplexing) is becoming a very popular multi-carrier modulation technique for transmission of signals over wireless channels. OFDM divides the high-rate stream into parallel lower rate data and hence prolongs the symbol duration, thus helping to eliminate Inter Symbol Interference (ISI). It also allows the bandwidth of subcarriers to overlap without Inter Carrier Interference (ICI) as long as the modulated carriers are orthogonal. OFDM therefore is considered as an efficient modulation technique for broadband access in a very dispersive environment. In this new information age, high data rate and strong reliability in wire-less communication systems are becoming the dominant factors for a successful exploitation of commercial networks. MIMO-OFDM (multiple input multiple output orthogonal frequency division multiplexing), a new wireless broadband technology, has gained great popularity for its capability of high rate transmission and its robustness against multi-path fading and other channel impairments. The arrangement of multiple antennas at the transition end and reception end results increase in the diversity gain refers the quality of signal and multiplexing gain refers the transmission capacity. Space time block coding used in this paper to transmit multiple copies of a data stream across a number of antennas and to exploit the various received versions of data to improve reliability of data transfer. The major challenge faced in MIMO-OFDM systems is how to obtain the channel state information accurately and promptly for coherent detection of information symbols. The channel state information can be obtained through training based, blind and semi blind channel Estimation. Interpolation is used to find the channel at signal frequencies.

Advantages Of Mimo System:

A MIMO communication system executes an average error probability that decays as where'd' is the diversity gain and is based on the assumption that at least one of the paths will not be in a deep fade state.

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Another advantage of a MIMO system is that, it is said to achieve multiplexing gain r, and the achievable rates scale as [r log (SNR)]. The multiplexing gain (unique for MIMO systems) is defined as the increase of the rate that can be attained through the use of multiple antennas at both sides of communication links, with respect to the rate achievable with single antenna system, without utilizing additional power.

Channel Type And Characterization:

The key measure of the rates that can be achieved by any communication system on the type of channel is shown. The receiver can either choose the best antenna to receive a stronger signal or combine signals from all antennas in such a way that maximizes SNR (Signal to Noise Ratio). Improves throughput and offers higher diversity that leads to multiplicative increase in capacity.

Channel type and Characterization:

Type of channel		Key measure of data rates
Rapidly varying	-	Ergodic Capacity
Slow varying (or) Fixed	-	Compound capacity Channels.

To improve the performance of MIMO channel; Orthogonal Frequency Division Multiplexing (OFDM) and Ultra Wide Band (UWB) techniques are combined with it and combinations like OFDM-MIMO and UWB-OFDM-MIMO has been proposed. Advantages of OFDM are spectral efficiency, mitigation of inter symbol interference and low cost receivers. The large bandwidth of UWB system (at least 500 MHz) results in resolution of different path delays to the order of Nano-seconds.

Present paper is organized into three sections. The first section deals with brief introduction to the UWB-OFDM-MIMO concept. The MIMO channel model has been explained in the second section. The third section covers the recent developments achieved by researchers in channel estimation techniques in multi-antenna environment .

The Mimo Channel Model:

Some of the benefits offered by MIMO channel areincreased capacity, beam forming gain, spatial diversity andspatial multiplexing, reduced interference and improvedreliability. The channel model can be based as site – specificOR site – independent. The generalized MIMO model is asshown below in figure 1. It has number of transmit andnumber of receiving antennas.

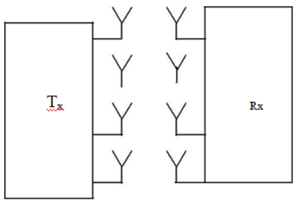

Fig. 1: MIMO communication system.

MIMO-ODFM transmission scheme:

The block diagram of the MIMO-OFDM transmission scheme is shown in figure 2.

In practice, OFDM systems are implemented using a combination of fast Fourier transform (FFT) and inverse fast Fourier transform(IFFT) blocks that are mathematically equivalent versions of the DFT and IDFT, respectively, but more efficient to implement.

An OFDM systems treats in source symbols (e.g., the QPSK or QAM symbols that would be present in a single carrier system) at the transmitter as though they are in the frequency domain.

These symbols are used as inputs to the IFFT block that brings the signal into the time domain. The IFFT takes in N symbols at a time where N is the number of subcarriers in the system. Each of these N input symbols has a symbol period of T seconds. Recall that the basis functions for an IFFT are N orthogonal sinusoids.

These sinusoids have a different frequency and the lowest frequency is DC. Each input symbol acts like a complex weight for the corresponding sinusoidal basis function. Since the input symbols are complex, the value of the symbol determines both the amplitude and phase of the sinusoid for the subcarrier.

The IFFT output is the summation of all N sinusoids. Thus the IFFT block provides a simple way to modulate data on to N orthogonal subcarriers**.**

The uwb-ofdm-mimo advantage:

The combination of MIMO with OFDM and UWB techniques emerged as the one among the most promising solutions for next generation wireless communication. It results in high level of spectral efficiency.

The UWB technology allows to overlay the GPS and IEEE 802.11 WLANs standards that coexist in the given frequency range 3.1-10.6 GHz without interfering them. It supports very high data rate of about 110 Mbps over a range of 10-15 meters and 480 Mbps at 2meters at very low power with a relative bandwidth of more than 20% .

The UWB frequency range is divided into several smaller sub bands of 500 MHz bandwidth with interleaved transmitted symbols as per FCC norms. This multiband approach not only improves the spectral flexibility but also reduces design related constraints

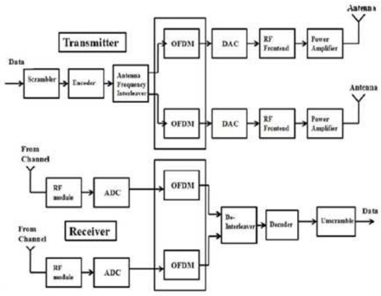

Fig. 2: Simplified MIMO-OFDM based UWB system.

Channel Estimation:

The most important research topic in the wirelesscommunications is the adaptive CE where the channel is rapidly time-varying. The time-varying multipath channel canbe represented by a tap-delayed line with time varyingcoefficients and fixed tap spacing. An adaptive algorithm is aprocess that changes its parameters as it gain more informationof its possibly changing environment.

In order to support a high data rate and a high system capacity,the new-generation mobile communication systems combinesthe orthogonal frequency-division multiplexing (OFDM) and multiple-input multiple-output (MIMO) techniques. TheOFDM technique is robustness against frequency-selectivefading channels and easy to implement the wide-band transmission, while the MIMO technique offers the multiplexingand diversity gain. The MIMO-OFDM technique combinethe advantages of the respective technique and is easy toimplement in actual systems. For coherent receivers, the pilot-aided channel estimation isusually applied to accurately and timely estimate the channel parameters. The receiver first estimates the channel information in the pilot position, and then obtains the channel information in the data position by some processing ways suchas interpolation, filtering and transformation. For the pilotaidedestimation, the excellent pilot plays a important rolein achieving a high-performance and low-complexity channel estimation.

In this paper, normalized least mean (NLMS) square andrecursive least squares (RLS) adaptive channel estimator aredescribed for MIMO OFDM systems. These CE methods usesadaptive estimator which are able to update parameters of theestimator continuously, so that knowledge of channel and noisestatistics are not required. This NLMS/RLS CE algorithmrequires knowledge of the received signal only. This can be done in a digital communication system by periodically transmitting a training sequence that is known to the receiver. Simulation results show that the RLS CE method has better performances compared NLMS CE method for MIMO OFDM systems. In addition, the utilizing of more multiple antennas at the transmitter and/or receiver provides a much higher performance compared with fewer antennas. Furthermore, the RLS CE algorithm provides faster convergence rate compared to NLMS CE method. Therefore, in order to combat the channel dynamics, the RLS CE algorithm is better to use for
MIMO OFDM systems.

OFDM Simulation Result:

The simulation model accepts inputs as text or audio files,binary, sinusoidal, or random data. The channel simulationallows examination of common wireless multipath channelcharacteristics such Rayleigh fading channel with variousDoppler Effect. Fig. 4 represents data streams after modulationmapping (at transmission end). Fig. 5 shows amplitude andphase spectrum of transmitted OFDM signal. Fig. 6 and Fig. 7depict amplitude and phase spectrum of received OFDM signalwith Dophlar spread 15 and 90 respectively. And, Fig. 8illustrates the received signal spectrum after FFT.

Methodology:

Matthew Welborn (Soysal, A. and S. Ulukus, 2007) suggests that, to achieve data rates close 1.5 to 2 Gbps in 500 MHz bandwidth it would require scaling to 64-QAM, where there is a significant difference in power efficiency between QPSK and 64-QAM. For instance, the minimum Eb/N0 required at the receiver is 9.6 dB for BPSK at 10^{-5} bit-error rate (BER) and almost 10 dB higher for 64-QAM at the same BER. The result is that high order modulation requires higher transmit power in order to provide equivalent BER at the receiver. The tight constraints on UWB transmit power result in significant range performance differences in realistic operating conditions. When the narrower bandwidth designs are to be extended to higher rates, the use of high order modulation and multiple antenna technologies can provide scalable and robust performance, but will also likely lead to increased complexity and power consumption. Systems that use wider bandwidths, such as direct sequence UWB, can use more efficient modulation and design approaches to provide wireless connectivity solutions that scale to even higher data rates with more scalable and lower complexity implementations.

Table 1: Summary of statistics of signals used.

Parameter	Values
Signal Bandwidth (KHz)	10, 12
Modulation	8 –PSK, QPEK
Subcarrier spacing (f Hz)	10, 11.72, 19,39,78
Number of subcarriers (K)	128,256,512,1024
Symbols/frame	16384
Blocks/frame	16,32,64,128
Guard interval (ms)	16, 25
Sampling frequency (MHz)	40 , 96
OFDM block duration (ms)	13,26,52,105
Coding	BCH, LDPC
Number of null carriers	96

Conclusion:

In this article we have studied the techniques developed and implemented by researchers in UWB-OFDM-MIMO environment in recent past. The simulations conducted by researchers vary in the type of algorithms chosen, the parameters considered, the nature of filter etc. Alamouti Schemes with antennas in 2x1 and 2x2 matrix was adopted by most of the researchers. In some cases we have noted application of 4x4 and 8x4 model also. The modulation technique adopted is either 16-QAM or BPSK.

The MIMO techniquehas shown an improvement by 3dB over the conventional single antenna system. The bit-rate and inter-carrier interference (ICI) were found better for large number of carriers (K=1024).

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